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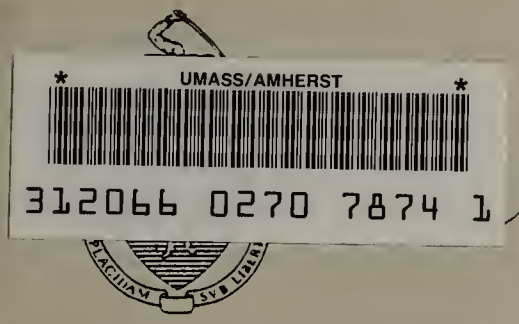
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The Commonwealth of Massachusetts
Massachusetts Centers of Excellence Corporation
One Ashburton Place -- Suite 2110
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GOVERNMENT DOCUMENTS
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PROCEEDINGS

Polymer Science & Plastics Technology Symposium

March 3, 1988
Sturbridge Sheraton Inn
Sturbridge, Massachusetts

	Banquet	Theatre	Class Room	Dimensions	Ceiling
Grand Ballroom	540	750	350	102′x60′	14′
Abbington Room	180	225	100	34′x60′	
Brookfield Room	180	225	100	34′x60′	
Cheshire Room	60	100	50	34′x30′	
Danforth Room	60	100	50	34′x30′	
"The Common"	160	200	100	60′x48′	10′
Sturbridge Room	70	100	50	20′x48′	
Charlton Room	30	50	20	20′x24′	
Brimfield Room	30	50	20	20′x24′	
Seminar Theatre	—	125	100	60′x27′	8′6″x11′
I	—	—	40	30′x27′	
II	—	—	40	30′x27′	
Southbridge Room	40	50	40	28′x25′	8′
Presidential Suite	—	—	—	20′x24′	8′
Executive I	Conference		12	20′x14′	8′
Executive II	Conference		12	20′x14′	8′
Hospitality Suites (2)	—	30	20	18′x26′	8′
Hawthorne Exhibit Hall (95 8′x10′ Booths)	1200	1600	700	110′x110′	16′

Sheraton Sturbridge Resort and Conference Center

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366 MAIN STREET
STURBRIDGE, MASSACHUSETTS 01566
TELEPHONE 617/347-7393

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Mass Centers of Excellence Corp.

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Undersecretary for Economic Development
Executive Office of Economic Affairs

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Professor, Plastics Engineering
University of Lowell

The Honorable Silvio Conte
U.S. House of Representatives

Anna Jane Harrison
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Mount Holyoke College

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Director, New Product Development
Monsanto Chemical Company

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University of Massachusetts, Amherst

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Polymer Project Director
Frances Eagle
Mass Centers of Excellence Corp
617/727-7430

Symposium Corporate Sponsors

Digital Equipment Corporation

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US Army Watertown MTL

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Other Sponsors

Society for the Plastics Industry

University of Massachusetts, Amherst
Polymer Science & Engineering Department

University of Lowell
Plastics Engineering Department

Massachusetts Institute of Technology
Program in Polymer Science and Technology

Symposium Agenda

Polymer Science & Plastics Technology Symposium

AGENDA

8:00AM	Registration and Poster Session Set Up
8:45AM	Welcome Megan Jones Director, MCEC
9:00AM	Chairmans Address Joseph G. Wirth Polymer Science & Technology Center of Excellence
9:30AM	Sessions I - IV Begin
9:30AM 5:00PM	Poster Session in Rooms Brimfield/Charlton/Sturbridge

SESSION I - Danforth/Cheshire Rm

9:30 STATE AGENCY WORKSHOP

Venture Capital Opportunities
Overseas Marketing
10:00 Course Development
Applied Research Grants
Product Develpment Finance
Local Finance Packages
10:30

11:00 FEDERAL LAB WORKSHOP
Opportunities for Interaction
US Army Natick RD&E Center

11:30 FEDERAL LAB WORKSHOP
Opportunities for Interaction
US Army Watertown MTL

11:30- Buffet Lunch in Court Yard
1:30

1:00 UPDATE: National Plastics Center and Museum

1:30 *A New Family of Rubber/Plastic Macro-Blends*
Typlax Products

2:00 *Reutilization of Automotive Engineering Plastics Scrap*
General Electric Plastics Group

2:30 RECYCLING SESSION

Creating a
Plastics Recycling
3:00 Network Within
New England

3:30-
4:00

SESSION II - Brookfield Room

Economic Solutions to Labor Intensive Quality Control
Instron Corporation

Artificial Intelligence Applied to Injection Molding Process
University of Lowell

Computer Design for Economical Manufacture of Injection Molded Parts
University of Massachusetts, Amherst

Pressure Verification of an Injection Molding Software Package
University of Lowell

Extrusion Additive Injection
Parker Hannifin Corporation

Overview of Injection Molding Screw Technology
University of Lowell

New Approach to Injection Molding Using Low Thermal Inertia Molding
University of Massachusetts, Amherst

Processing Of Polymer Based Composites
Massachusetts Institute of Technology

Effect of Processing History on Toughness in Polyamide Blends
Massachusetts Institute of Technology

Incremental Draw Process for Improved Fiber Products and Productivity
Tufts University

Plasma Nitriding Critical Parts of Plastics Processing Machinery
Northeastern University

SESSION III - Abbington Room

Advanced Materials Based On Polymeric Liquid Crystals
University of Lowell

Polysilanes : Novel Self-Developing Photo resists
Digital Equipment Corporation

Molecular Design Laboratory Department of Chemistry
University of Lowell

PEEK: Prototype for High Performance Semicrystalline Thermoplastics
Massachusetts Institute of Technology

New Polymeric Materials for Use In Electrical Applications
Spire Corporation

Processable, Environmentally Stable, Intrinsic Conducting Polymers
Polaroid Corporation

Optical Processes in Polydiacetylene: The Structural Basis
GTE Laboratories

Mech Properties of Pressure Sensitive Adhesives vs Stand Performance Tests
Monsanto Chemical Company

Surface Modification of Synthetic Fibers for Elastomer Reinforcement
Tufts University

Composite Process Applications
Worcester Polytechnic Institute

New Fracture Mechanics Specimen: The Buckled Plate- for Composites
University of Massachusetts, Amherst

SESSION IV - Seminar Theatres

Water Purification by Electron Irradiation Using PE oxide
Massachusetts Institute of Technology

Membrane Science in Massachusetts: History, Status and Future Needs
Millipore Corporation

Synthesis of New Polysilarylene-siloxanes as Gas Separation Membranes
University of Massachusetts, Amherst

Challenges Using Biodegradable Polymers in Drug Delivery Systems
Northeastern University

Polymeric Matrices for Regeneration of Skin and Periperal Nerve
Massachusetts Institute of Technology

Biopolymer Applications for Materials
US Army Natick RD&E Center

Functionalized Biopolymers for Removal of Toxic Metal Ions
Cape Cod Research

Characterization of Marine Bioadhesive Proteins
Boston University

HPLC-LALLS of Alkaline Phosphatase Enzymes and Related Biopolymers
Northeastern University

Vapor Sorption in NR Samples Containing Carbon Black
Tufts University

Microindentation Technique for Measuring Polymer Film Adhesion
University of Massachusetts, Amherst

Centers of Excellence

Polymer Awards

The Commonwealth of Massachusetts
Massachusetts Centers of Excellence Corporation
One Ashburton Place -- Suite 2110
Boston, Ma. 02108

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MISSION STATEMENT

POLYMER SCIENCE CENTER OF EXCELLENCE

To establish and ensure support for leading-edge educational and technology programs and projects in polymer science which have been judged to hold significant economic potential for the Commonwealth; judged to be in the best interest of the citizens of the state; and, in addition, hold the potential to rapidly translate scientific knowledge into a usable technology.

Specifically, to:

1. Support research and development projects at the leading-edge of polymer technology.

2. Support innovative projects from small- and medium-sized companies focused on polymer-related business.

3. Support technically feasible projects which use or modify polymers to enhance environmental conditions.

4. Promote excellence in education and applied research at public and private educational institutions within the state which emphasize polymer science and technology in their curriculum.

5. Act as a resource in areas related to polymer science and technology for state government and related agencies.

To Be Ratified at March 18, 1988 Meeting

5079L

The Commonwealth of Massachusetts
Massachusetts Centers of Excellence Corporation
One Ashburton Place -- Suite 2110
Boston, Ma. 02108

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GRANT ROUND STRATEGY

POLYMER SCIENCE CENTER OF EXCELLENCE

- **Advanced materials:**

  the development of polymeric materials for use in such areas as optical, medical, electrical, composite, etc., applications; replacement of strategic materials; development of test procedures and characterization techniques to more adequately measure critical properties.

- **Polymer processing and fabrication technology:**

  productivity enhancements related to any aspect of the manufacturing process; software enhancements or developments related to research, development and manufacturing of polymers; equipment modification to improve processibility; reinforcement of high stress areas to improve durability; understanding structure/processing relationships; quality control techniques to monitor polymer processing and fabrication.

- **Biopolymer technology:**

  basic research on properties; commercial applications; modification and/or analysis of the molecular structure; biological sources of new monomers and polymers.

- **Environmental considerations pertaining to polymers:**

  recycling; waste disposal; degradation studies; source reduction considerations; construction of experimental equipment to incinerate polymers for residential or industrial use; the use of polymeric materials in waste separation technology.

  The submission of papers related to the development of new technologies that can lead to high value products in recycled plastics is strongly encouraged during this grant round.

To Be Ratified at March 18, 1988 Meeting

5081L

GRANT AWARDS IN POLYMER SCIENCE
Awarded September 15, 1986

1
Development of an Artificial Intelligence System for Injection Molding
University of Lowell/Gigamos Systems

The ultimate goal of injection molding manufacturers is to achieve a high quality, zero defect product coupled with maximum productivity of the manufacturing process. This project will attempt to adopt artificial intelligence (the use of computer hard/software to analyze and regulate a process) to the injection molding process using a closed loop and sophisticated on-line system.

2
Magnetic Absorbents for Waste Water Treatment
Massachusetts Maritime Academy/Cape Cod Research

The objective of this research project is to chemically modify biopolymers to efficiently extract heavy metals from industrial waste water effluent. This project, if successful, would create environmental conditions which would advance Massachusetts' ability to maintain and enhance its plating industry without dangerously polluting Commonwealth waters.

3
Gas Separation Membranes from Silarylene-Siloxane Polymers
University of Massachusetts, Amherst/Millipore Corporation

This project will synthesize, characterize and test a novel group of polymers for the economic separation of oxygen and nitrogen gas.

4
Efficiency Improvement Extension Service for Polymer Processing Industry
University of Lowell/Automated Assemblies, Dynisco Inc.

In order for Massachusetts' injection molding, extrusion and blow-molding manufacturers to maintain a competitive advantage with foreign countries, advances in productivity and manufacturing efficiency are necessary. This proposal creates an Extension Service at the University of Lowell Plastics Engineering Department which will provide specialized hands-on training and process optimization services for industry personnel using current processing facilities supplemented with state-of-the-art equipment.

GRANT AWARDS IN POLYMER SCIENCE
Awarded September 15, 1986

5
Artificial Intelligence Applied to Injection Mold Design
University of Massachusetts, Amherst/General Electric Plastics

Ten years ago the design of a mold as a template for a product was an empirical process in which an experienced mold designer learned where best to position mold cavities, runners, gates, etc. by a trial-and-error approach. This proved both expensive and time-consuming, sometimes taking up to 10-15 prototype cuts to achieve a production ready mold. Computer programs have been written to design molds, many times within 3-5 prototype cuts. Expert mold designers are still needed to advise on the final cuts since the art of moldmaking is still not a predictable science. This project would incorporate the expert mold designer's knowledge into existing computer programs to further improve and automate the design of injection molds by using artificial intelligence in tandem with computer-aided engineering design.

6
Polymer Science and Engineering Lab at University of Massachusetts, Amherst
University of Massachusetts, Amherst/General Electric, Monsanto

University of Massachusetts, Amherst is a recognized leader in the field of polymer science and engineering research. Currently this department's facilities are badly overcrowded. This project proposes to renovate approximately 1700 square feet of unused basement into a useable polymer science research laboratory. 1200 square feet will be assigned to the newest faculty member. The remaining area will be used as a thermal analysis lab.

7
Massachusetts Mold Analysis Research Consortium
University of Lowell/General Electric, Monsanto, Digital Equipment Corporation

The use of computer technology in the flow and cooling analysis of the injection molding process is revolutionizing part design, mold design/machining and efficiency of part production in the injection molding industry. This project establishes a research consortium to provide a "service center" for Massachusetts-based companies in supplying consistent raw material test data, access to computer predictions of filling/cooling for injection molds, and educational programs and engineering/design support.

GRANT AWARDS IN POLYMER SCIENCE
Awarded August 4, 1987

8
A New Approach to Injection Molding
University of Massachusetts, Amherst/Monsanto, Polaroid

The project seeks to improve the quality of an injection molded part by using a Low Thermal Inertia Molding (LTIM). LTIM uses thermoelectric plates on the surface of the mold to rapidly heat and cool the injected part in order to minimize its surface stress and improve weldline fracture properties.

9
Evaluation, Optimization and Implementation of Polymer Recycling Technologies in the Commonwealth of Massachusetts
University of Lowell/New England CRinc

The problems associated with plastics waste (household, marine) are well-publicized. Many states are passing legislation to regulate, reduce or eliminate easy-to-purchase plastic consumer products. This project supports the establishment of a recycling technology for the Commonwealth of Massachusetts. Aspects of the project include investigation of advanced methodology for the identification of plastics in the wastestream, process improvements related to increased throughput and improved integrity and the feasibility of mixed plastics technology.

10
Novel Polysilanes for Photolithographic Applications
University of Lowell/Digital Equipment Corporation

The preparation and characterization of novel polysilanes will be conducted to determine the utility of these compounds in the fabrication of microcircuits. The successful development of these novel polymers will have a significant impact on the manner in which future microcircuits are fabricated by yielding superior products at substantially lower production costs and greater microcircuit yields. The development of these polymers may substantially change the way in which microcircuits are fabricated in the future.

GRANT AWARDS IN POLYMER SCIENCE
Awarded August 4, 1987

11
Computer-Aided Project Design for Economical Manufacture
University of Massachusett, Amherst/Digital Equipment Corp, Xerox Corp

Productivity increases are typically identified only with investments in the latest production methods and with increased automation. However, productivity improvements are equally influenced by the design of the products for ease of manufacture. Polymer processing by injection molding offers opportunities for large cost-savings by using a technique that will improve the design of a product for its ease of manufacture. The goal of this project is to create software that will indicate the relative costs of producing a part by taking into consideration such factors as the complexity of mold construction, equipment operation and material selection. Those factors that add substantial cost or time to the production process will be flagged so that the product designer may be guided to avoid difficult or costly manufacturing processes.

12
Defective Part Prediction for Injection Molding
University of Lowell & Scientific Systems, Nypro, Dynisco

The ultimate goal of the injection molding process is to produce zero defect parts at the highest possible manufacturing rate. This can only be accomplished if on-line defective parts are identified as rapidly as possible and immediate on-line corrective action is taken. Current technology requires real-time inspection and monitoring systems which are too expensive for practical use. The objective of this project is to apply several recently developed techniques in statistical modeling and pattern recognition to determine statistically significant relations between observed process variables and specific types of part defects (e.g., surface imperfections, out-of-tolerance dimensions, etc.).

13
Fiber Optic Switching Using Polymer Nonlinear Optic Materials
University of Lowell/Foster-Miller

A strong need and large potential market exist for fiber optic switching devices to control light signals carried by optical fibers for telecommunications, computer interconnections, data links and local area networks. Today few such devices exist. This project is aimed at demonstrating and producing a practical, low-cost, all-optical switch based on polymeric nonlinear materials.

GRANT AWARDS IN POLYMER SCIENCE
Awarded August 4, 1987

14
Metal Oxide Ceramics from Organometallic Polymers and Copolymers
University of Massachusetts, Amherst/Norton Company

The need for high performance ceramic fibers for metal and ceramic matrix composites has fueled a recent upsurge of organometallic precursors for sophisticated fabrication of advanced ceramic materials. The purpose of this project is to develop new organometallic polymers that will be used in the preparation of high purity, high strength ceramics. This approach may be a desirable alternative to the present process which is time-consuming and creates structural flaws in the final ceramic product.

15
Optical and Engineering Properties of Molecular Composites Comprising Liquid Crystal and Vinyl Polymers

University of Massachusetts, Amherst/Polaroid

Composite theory indicates that the reinforcing ability of a fiber is dependent on the fiber's length-to-width ratio. Theoretically, ultimate reinforcement may be achieved when a single, strong, stiff molecule acts as a fiber at the molecular level. This project is a novel attempt to generate molecular composites comprised of rod-like liquid crystalline polymers imbedded in an amorphous, flexible-chain matrix.

GRANT AWARDS IN POLYMER SCIENCE
Awarded August 4, 1987

16
Demonstration of Sub-Micron Fiber Containing Composites
University of Lowell/Hyperion Catalysis

Reinforcing fibers used in composite technology exist as continuous filaments, chopped fibers or as whiskers. This project introduces a new category of smaller cost-competitive reinforcing fibers, called fibrils, into the marketplace. Researchers will conduct experiments to determine if the small-sized fibril enhances the mechanical properties of composites. Besides this practical application this project is also interesting from an academic standpoint to see if these extremely small fibrils adapt to existing composite theory models.

17
Resource Facility for Increasing the Service Life of Critical Parts in Plastics Processing Machinery by Plasma Nitriding
Northeastern University/General Electric Plastics, Packaging Industries, Composite Container Corporation

A major cost factor associated with the production of consistent plastic products is the wear of critical parts in the processing equipment which directly affects the dimensional stability or consistency of the resulting plastic product. This project will reduce part wear rate by using a plasma nitriding process as a metal surface treatment to enhance the hardness and wear resistance of the nitrided metal part.

Received Abstracts

for Presentation

State/Quasi-Public Agencies

MASSACHUSETTS CENTERS OF EXCELLENCE CORPORATION

Megan Jones, Director
One Ashburton Place, Room 2110
Boston, Massachusetts 02108
617/727-7430

The Massachusetts Centers of Excellence Corporation (MCEC) is a quasi-public agency established in 1985 to stimulate economic development by promoting new technologies and new applications of existing technologies through education/industry/government partnerships. Initially four technologies were identified - biotechnology, marine science, polymer science, photovoltaics - technologies in which Massachusetts already enjoyed an academic and/or industrial edge and which had demonstrated long-range potential for growth.

MCEC's major goals are:

- To aspire to the highest standards of excellence in scientific research and industrial applications in specified areas of emerging technologies that hold substantial promise for the future economic growth of the Commonwealth.

- To promote a spirit of cooperation and partnership between academic and research institutions and private industry in order to speed the transformation of scientific discovery into usable technology.

MCEC operates with a dual system of boards. Nine directors, three each from academia, private industry and government serve on the Corporation Board. Chaired by the Secretary of Economic Affairs, the MCEC Board sets policy and makes funding decisions. The technology boards, which are similarly constituted, are charged with developing specific strategies to implement the MCEC goals.

MCEC received its first legislative appropriation of $1.38 million for the 1987 fiscal year. Three technology boards - biotechnology, marine science, and polymer science - adopted a competitive research and development grants program which requires a partnership between educational/research institutions and one or more industries. By leveraging state resources, MCEC funded 20 projects in September, 1986 with $1 million in state funds to which the industry-education collaborators contributed nearly $2 million. The FY'88 budget appropriation totaled $3.34 million which included money for the renewal of multi-year projects funded in the first round as well as money for a second grant round. The MCEC Board voted to fund 21 new proposals in June 1987 with $2.7 million committed by the industry/education collaborators. The implications of these forty-one projects promise to enhance crop production, the delivery of health care, manufacturing production processes and the quality of the environment.

In response to a gubernatorial request to consider a new center, the MCEC Board voted in March, 1987 to add a Center for Applied Technology (CAT) that will address the goals of MCEC by revitalizing small and medium-sized manufacturing industries through the application of new technologies. The CAT Board representing labor, industry, education and government, met for the first time in December, 1987 and has embarked on an ambitious and multi-faceted strategy of assistance to manufacturing firms.

MASSACHUSETTS TECHNOLOGY DEVELOPMENT CORPORATION

John F. Hodgman, President
84 State Street
Boston, Massachusetts 02109
617/723-4920

Massachusetts Technology Development Corporation (MTDC) is an independent state agency created by law in 1978 to provide a source of capital to new and expanding technology-based companies within the Commonwealth and, thereby, to provide a substantive number of viable jobs. It has accomplished this mandate by operating as a venture capital firm, leveraging co-investment by private venture investors.

MTDC finances companies which have the capacity to generate significant employment growth, but which have been unable to secure from private sources sufficient capital on affordable terms to fund their start-up or expansion.

Since 1979 MTDC has invested in 45 companies, 7 of which are now traded on the public stock markets. Within its current portfolio, MTDC's investments have helped to create more than 1,700 new jobs. The total employment among active companies is over 2,500, which in turn accounts for a total annual payroll in excess of $77 million and an estimated total annual tax revenue of over $14 million to the Federal Government and over $3 million to the state.

MTDC has established policies and practices to complement, not to compete with, private financial institutions. As a result, by the end of Fiscal '87, MTDC had invested a cumulative total of $9.9 million, which leveraged more than $44.5 million of private investment at the initial stage of financing. Subsequent rounds of financing in MTDC portfolio companies brought the cumulative private dollars invested to $184 million, representing a leverage factor of $18.59 for every $1 of MTDC investment.

5460L

MASSACHUSETTS PRODUCT DEVELOPMENT CORPORATION

Samuel Leiken, President
171 Milk Street
Boston, Massachusetts 02109
617/727-1133

The Massachusetts Product Development Corporation (MPDC) is a quasi-public corporation designed to preserve and create employment in the industrial sector by stimulating new product and new process development among mature industries. A public/private partnership, MPDC is operated by a private board of directors with funding provided by the Commonwealth of Massachusetts.

Historically, Massachusetts has relied on the creativity and ingenuity of its citizens to be competitive in the market place. MPDC was established by the legislature to build upon our tradition of innovation by removing obstacles to new product development encountered by small and mid-sized manufacturing firms.

Manufacturers have had difficulty securing investment capital to diversify with new products or processes. The explanation for this capital shortage lies in the size of the perceived risk of such investments relative to the expected level of return, especially when compared to "safer" investments offering attractive returns. The problem is particularly acute among medium and small firms which lack the retained earnings to invest in new product development, but whose capital needs are insufficient to generate adequate return to cover the fixed costs associated with borrowing.

MPDC was established to meet the needs of companies who face declining markets, foreign competition or automation and want to diversify with new products to continue to prosper. MPDC makes a financial investment in exchange for royalties in the product. If the product does not succeed, the company is not saddled with debt. If the product is a success, the MPDC shares in that success through its royalty income. Investment funds may be used for commercialization of the product. This includes design improvements, development of a manufacturing process, marketing, sales and distribution.

Priority for investments will be given to those companies likely to experience a loss of employment in their existing businesses and whose proposed product is to be used to maintain or increase employment or to retrieve jobs sent abroad and thus reduce the social and public costs of employment dislocation.

An applicant must be able to demonstrate that it has been unable to secure sufficient private capital on reasonable terms to finance its proposed product. All applicants must be located in Massachusetts or be willing to relocate to Massachusetts. In addition, they must agree to the social compact, which requires ninety days notice in the event of a plant closing. MPDC is not permitted to finance research and development. A company must have a prototype to be eligible. Application forms and a suggested business plan outline can be obtained by writing or calling MPDC.

BAY STATE SKILLS CORPORATION

Susan K. Moulton, Executive Director
101 Summer Street
Boston, Massachusetts 02110
617/292-5100

The Bay State Skills Corporation (BSSC) is a quasi-public corporation created in July 1981 to respond to the rapidly changing nature of our economy. Its basic purpose is to award grants to educational institutions which link up with one or more private companies and together train people for jobs in high growth fields.

Since 1981, BSSC's mission has grown and developed. Its mandate is:

- to encourage and facilitate the formation of cooperative relationships between business and industry, labor, government and education to develop and expand programs of skills training that are consistent with employment needs;

- to provide grants-in-aid to education and training institutions, to be matched with private sector financial support, to fund skills training programs in growth occupational areas;

- to collect and disseminate information on present and future employment needs as well as the availability of skills training and education in these areas; and

- to conduct conferences and studies which will increase communication and information on employment needs of the Commonwealth.

The activities of the Corporation are governed by an 18-member Board of Directors. The Board is chaired by Joseph D. Alviani, State Secretary of Economic Affairs and is made up of individuals from business and industry, skills training, government, education and labor.

The BSSC funds programs in a wide variety of occupational areas: machine operation; precision manufacturing; nuclear medicine technology; respiratory therapy; word processing; data entry, microwave engineering; computer-aided drafting and design; electronics; and advanced automation and robotics. The training spans entry level, retraining and employee upgrade training, as well as advanced-level university and college education. These programs foster BSSC's goal to expand the number of skilled workers available for Massachusetts companies.

The training can take place at community colleges, vocational schools, JTPA skills centers, four-year colleges, universities, and community-based manpower organizations throughout the state. The BSSC acts as a funding organization and a catalyst for public-private training partnerships.

MASSACHUSETTS OFFICE OF BUSINESS DEVELOPMENT

Byron Battle, Undersecretary for Economic Development
100 Cambridge Street, 13th Floor
Boston, Massachusetts 02202
617/727-3221

The Massachusetts Office of Business Development (MOBD) implements programs and actions which support a vibrant Massachusetts economy as measured by the quality of jobs created and by the success of Massachusetts companies. MOBD programs facilitate access to state business support services, help small and entrepreneurial businesses to develop and grow, support the application and development of technology by Massachusetts companies, and support the development of an increasingly skilled workforce. MOBD cooperates with state agencies, business groups and individual businesses with which it has mutual interests and objectives.

MOBD is organized into four areas of activity: business services, manufacturing development, small and entrepreneurial business development and market research.

The Business Services Division provides "one stop shopping" by coordinating negotiations and delivery of services provided by the state. In addition, it facilitates site identification and selection process by providing to business detailed real estate information as well as financing assistance.

The Manufacturing Development Division develops and coordinates programs to support targeted industry sectors. The current targeted sectors are the metalworking industry and the plastics industry.

The metalworking industry program, called the Massachusetts Metalworking Partnership, has three components: (1) an integrated labor training system statewide using a technically updated curriculum and providing lifelong training to all levels of the workforce in the metalworking industry; (2) a marketing program by MOBD to develop sales opportunities for metalworking firms; and (3) a technical assistance program led by the Massachusetts Center for Applied Technology. The Partnership is a cooperative effort of business, education and training institutions, labor, quasi-public agencies and state government. The projects developed will be "demand-driven" by industry with the energy and direction coming largely from the companies themselves, thereby placing state government in a supportive rather than directive role.

The Small and Entrepreneurial Business Development Program supports small business development through information dissemination, consultation and referral.

The Market Research Division compiles an industrial database for manufacturing competitiveness program, assists in the promotion of targeted manufacturing industries, and responds to requests for demographic statistics, employment and wage data, tax comparisons and economic development publications.

OFFICE OF INTERNATIONAL TRADE AND INVESTMENT

Andrew Bagley, Director
100 Cambridge Street, 9th Floor
Boston, Massachusetts 02202
617/367-1830

International trade and investment are critical contributors to the state's prosperity and to its long-term economic diversification. Exports alone account for an estimated 12-14% of the gross state product, totalling $9-10 billion in revenues each year, and are responsible for approximately 150,000 jobs in the Commonwealth.

Massachusetts' international competitiveness has, therefore, become a focal point of the state's economic development strategy for the 1980's. Recognizing the importance of expanding world markets for Massachusetts' firms as well as the potential contribution of foreign manufacturing to the state's local economy, Governor Michael S. Dukakis established the Office of International Trade and Investment in May, 1984. To advise this program, he appointed the Massachusetts International Trade Council, Inc., a not-for-profit institution composed of leaders from Massachusetts' international trade and investment community.

The mandate given to the Office and the MITC by the Governor is to develop a model state program to enhance the contribution of international trade and investment to Massachusetts' economic future. The Governor's guidelines are for the Office of International Trade and Investment to develop a program of focused and business-like assistance to help the state's smaller and medium-sized companies identify overseas buyers. Similarly, with respect to foreign investment into Massachusetts, the state's economic development strategy calls for solicitation of foreign manufacturing investment, particularly into our traditional industries and into the state's areas of opportunity.

In addition to its principal activities in export development and investment promotion, the Office of International Trade and Investment serves as the Commonwealth's international representative, responsible for assisting official foreign delegations visiting the state, administering special bilateral relationships with other regions of the world, and coordinating international educational and cultural exchanges that directly involve the Commonwealth.

Industry

INDUSTRY ABSTRACTS
(Alphabetical Order)

COMPANY	ABSTRACT TITLE
Cape Cod Research	Use of Functionalized Biopolymers for the Efficient Removal of Toxic Metal Ions
Digital Equipment Corp.	Polysilanes as Novel Self-Developing Photoresists
General Electric Company	Re-utilization of Automotive Engineering Plastics Scrap
GTE Laboratories Corporation	Linear and Nonlinear Optical Processes in Polydiacetylenes: The Structural Basis
Instron Corporation	Rheology Software for Instron Capillary Rheometers
	Economic Solutions to Labor-Intensive Quality Control
Millipore Corporation	Membrane Science in Massachusetts: History, Status and Future Needs
Monsanto Chemical Company	New Nylon/ABS Alloys: Structure-Property Relationships
	Mechanical Properties of Pressure Sensitive Adhesives and Relationships to Industry Standard Performance Tests
	Accelerated and Outdoor Weathering of an ASA Polyblend: Correlation and Kinetic Model for Color Change
Parker Hannifin/Zenith Div	Extrusion Additive Injection
Polaroid	Processable, Environmentally Stable, Intrinsically Conducting Polymers
Spire Corporation	New Polymeric Materials for Use in Electrical Applications
Typlax Products, Inc.	Plastics, The Environment and a New Family of Rubber/Plastic Macro-Blends
US Army Natick RD&E Center	Biopolymer Applications for Materials

5171L

USE OF FUNCTIONALIZED BIOPOLYMERS FOR THE EFFICIENT REMOVAL OF TOXIC METAL IONS

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The efficient removal of heavy metals from wastewater into the low part per billon (ppb) range is a difficult task on a practical scale. State and federal governments are currently forcing industries and municipalities to meet such levels in any effluent waters. Existing techniques for achieving ppb levels such as membranes are expensive and take a relatively nigh level of skill to operate.

The proposed paper deals with an efficient, cost-effective procedure for achieving these low concentration goals. It is based upon the use of low-cost biopolymer beads which in functionalized and unfunctionalized form rapidly remove heavy metals. Results are presented for copper (II) removal in tne presence or absence of an excellent chelating agent, ethylene diamine tetra-acetic acid (EDTA). In addition, the effect of pH variation upon uptake rate and ultimate exchange capacities is reported. The preparation of the beads with internal magnetic motes is discussed including the effects of these motes on uptake. Finally, the transition from experiments to actual trials in the field at a local electroplating plant are discussed. The future work to be done in the field and in the laboratory to expand the applicability of this promising technology is outlined.

POLYSILANES AS NOVEL SELF-DEVELOPING PHOTORESISTS

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High molecular weight polysilane photopolymers have been the subject of increasing investigation over the last few years. It has been shown that polysilanes can be photoablated with modest intensity levels of deep UV radiation. This irradiation process produces a photoscission of the polymer'sbackbone structure followed by volatilization of the resulting photoproducts. Typical carbon based photopolymers do not exhibit this characteristic when irradiated with deep UV radiation.

The photosensitivity of polysilanes to deep UV radiation suggests their application in photolithography as self-developing photoresists. The microelectronics industry is expected to be the chief beneficiary of such a photoresist.

Successful engineering of polysilanes for photolithography will mean that the wet developing step common to the process today will be unnecessary. Hence, one might expect a superior image quality for polysilanes as compared to carbon-based photoresists. Because the photopolymer can essentially be photo-stripped away layer-by-layer, high aspect ratio structures should be possible. With present wet developable carbon-based photoresists, aspect ratios higher than one-to-one are difficult to achieve in all but very thin films.

A brief overview of polysilanes and their industrial applications will be presented followed by a discussion of experimental results. The present experimental effort has targeted both basic material properties as well as performance in engineering process development steps. The thermal properties have been selected as the focus of this presentation. Glass transition temperatures and decomposition temperatures for many of the polysilanes have been determined by differential scanning calorimetry and thermogravimetric analysis respectively.

RE-UTILIZATION OF AUTOMOTIVE ENGINEERING PLASTICS SCRAP

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New innovative approaches and smart outlets will be required for re-utilizing engineering plastics from the scrap of automotives and automotive parts.

Since the Middle East embargo crisis of the late seventies, the use of plastics in cars has accelerated, increasing from 150 lbs. to 300 lbs. per car in five years and projected to be 500 lbs. by the early 1990's. Engineering thermoplastics usage will increase from 10% of the automotive plastics to 30% in the same period. The annual U.S. automotive scrap would contain 500MM lbs. of Engineering plastics by mid 1990's to as much as 1.2 billion lbs. by the early 21st Century.

A program has been initiated at GE Plastics to develop advanced recycle fabrication technology for recovering, rejuvenating, and reentering these engineering plastics scrap back into "longer life cycle" applications for industrial and consumer usage.

This paper will discuss initial findings and the proposals for joint government, academic and industrial research for re-utilizing engineering thermoplastics scrap.

LINEAR AND NONLINEAR OPTICAL PROCESSES IN POLYDIACETYLENES: THE STRUCTURAL BASIS

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The polydiacetylenes (PDA) are a class of crystallographically ordered polymers, a consequence of their synthesis by means of a lattice-controlled solid state polymerization, with conjugated backbones. The latter property leads to an electronic structure which manifests intense visible absorption and novel photoelectronic properties, as well as the largest nonresonant third order nonlinear susceptibility $X^{(3)}$ of any material. The latter property is relevant to all-optical signal processing. Associated with the nonresonant $X^{(3)}$ is a subpicosecond response time. Further, certain urethane-substituted PDA exhibit thermochromic behavior.

The structural origin of thermochromism in the PDA of the bis-ethylurethane of 5,7-dodecadiyn-1,12-diol (ETCD) is traced to a lattice expansion near the transition by means of temperature dependent x-ray diffraction. The role of local side chain crystal packing in PDA spectral shifts is discussed with particular reference to the thermochromic poly-ETCD and PDA from 1,6-di-N-carbazolyl-2,4-hexadiyne (DCH) and 1,1',6,6',-tetraphenyl hexadiynediamine (THD).

Resonance Raman spectroscopy is a sensitive probe of PDA electronic stucture and provides additional relevant detail concerning the spectral shifts discussed above. Room temperature (20 °C) resonance Raman spectra of poly-ETCD have been studied as a function of sample processing using six different excitation wavelengths. These spectra provide direct experimental evidence for the coexistence of two electronic states in poly-ETCD at room temperature.

RHEOLOGY SOFTWARE COUPLED WITH INSTRON CAPILLARY RHEOMETERS

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As the use of plastics continues to grow, the need for rheological characterization and measurement will also grow. In R&D and Quality Control, rheology is moving more and more towards becoming a science. The capillary rheometer is playing a more significant role than ever before in aiding scientists in predicting plastics performance before setting up costly production runs.

QC people use the capillary rheometer to monitor batches of material being fed to various types of extruders, thus being able to minimize the number of defective parts. However, rheology calculations can become tedious and time-consuming, thus Instron has developed rheology software which runs on IBM PC and compatible computers and includes either manual or automatic operation of Instron capillary rheometers. Test procedures and steady state results can be stored and specific correction factors can be applied at the user's convenience.

The software includes the calculation of activation energy, power law index, Rabinowitsch factor, Bagley correction factor, and the subtraction of barrel drag from results.

The basic theory behind rheological calculations and corrections combined with the use of the Instron software with a capillary rheometer will be covered in detail.

ECONOMIC SOLUTIONS TO LABOR-INTENSIVE QUALITY CONTROL

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Material classification, product integrity and consumer scrutiny are all factors leading to the demand for larger quantities of highly accurate data. In recent years the demand for increased quality has caused many manufacturers to realize that insuring product quality meant the increase in verification testing. New, more sophisticated instruments supported by highly trained laboratory personnel have driven the cost of quality control material evaluations steadily upward.

The development of automated laboratory testing instrumentation has revolutionized the materials evaluation laboratory. Common tests used to evaluate the tensile and flexural strength of plastic test specimens can be performed by unattended, fully automated laboratory instruments while highly trained technicians are free to perform other, more sophisticated tests.

Specimen storage, specimen identification, specimen manipulation, test performance, data gathering and analysis and report generation are fully automated. Test results are immediately available for process control decision making and through electronic data storage, information is stored for long term trend analysis.

MEMBRANE SCIENCE IN MASSACHUSETTS: HISTORY, STATUS AND FUTURE NEEDS

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Synthetic membranes are used in a wide variety of separations applications, from the sterilization of fluids by removal of bacteria, to the separation of oxygen and nitrogen from air. Massachusetts-based firms played key roles in the development of this industry. The growth of membrane separations worldwide has been paralleled by growth in Massachusetts. The present role of Massachusetts-based firms in this multifaceted, international business will be discussed.

As users become more sophisticated and the uses of synthetic membranes becomes more varied and specific, the need for research in material science is increasing. Presently identified needs and future trends in the industry will be presented.

NEW NYLON/ABS ALLOYS: STRUCTURE-PROPERTY RELATIONSHIPS

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A new family of polymer alloys, Triax™ engineering thermoplastics, has been commercialized by Monsanto. The first members of the family are Triax 1000 plastics which are compatibilized nylon/ABS alloys. Mechanical properties will be discussed as a function of degree of compatibilization, volume fraction of the polymer phases and morphology. Effects of compatibilization on toughness in the absence and presence of triaxial stress states will be discussed.

The rather unique co-continuous morphology of the commercial grades generated by synergism between alloy component phases results in superior toughness. The morphology will be shown to be co-continuous between the nylon/ABS volume fractions of 35%/65% to 65%/35%. Outside this range, the lesser component becomes a dispersed particulate phase in the larger volume component matrix.

Izod impact strength is optimum in the co-continuous region and is lower in the discontinuous regions. Most other properties are independent of morphology and change monotonically; they can be estimated with the "volume fraction" rule and component properties. Detailed performance data for the recently commercialized materials will be discussed.

MECHANICAL PROPERTIES OF PRESSURE SENSITIVE ADHESIVES AND RELATIONSHIPS TO INDUSTRY STANDARD PERFORMANCE TESTS

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Pressure-sensitive adhesives (PSA) play an important if sometimes obscure role in many and wide-ranging applications including: safety markings, weatherizing materials, automobile assembly, advertising decals, packaging integrity and sustained delivery of medication. In the era of synthetic polymers, PSA's have evolved from a traditional cottage industry based on empirical experience into a technology-based specialty industry which continues to show considerable growth based on new applications. New products displace old ones with a half-life of 2 to 3 years.

To meet new challenges and supplement an extensive experience base, leading adhesive manufacturers are utilizing state-of-the-art characterization methods to illuminate the molecular mechanisms leading to product performance. Recently, we have measured dynamic mechanical and direct tensile properties on "bulk" samples of both commercial and laboratory acrylic industry standard "application" peel and shear properties.

Correlations were established showing that more than half of the range of performance properties available in commercial acrylic PSA's are controlled by bulk mechanical properties of the adhesive polymer. A few exceptions stand out, sometimes for clear-cut reasons. The results can be used to relate PSA performance to well-known concepts in other areas of polymer material science, e.g., fracture toughness, rubber elasticity and rheology and also to key variables in the adhesive formulation or selection process.

ACCELERATED AND OUTDOOR WEATHERING OF AN ASA POLYBLEND: CORRELATION AND KINETIC MODEL FOR COLOR CHANGE

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Polymers are susceptible to degradation via photo-oxidation reactions when exposed to environmental elements. The most easily noticeable result of the degradation is color change - a great concern from the aesthetic point of view. Studies of degradation using terrestrial sunlight exposure are too time-consuming to be practical. Therefore, accelerated weathering using artificial light sources is generally practiced. In order to predict the service performance of polymeric materials from the accelerated weathering information, knowledge of the relationships among the various accelerated artificial weathering and the natural outdoor exposures is needed.

Correlations on colorfastness of an ASA polyblend were studied, using three accelerated weathering devices and outdoor under-glass (UG) exposure in Arizona and Florida.

For nine colors, the exposure required for color change to reach an average delta E (dE) of 1.9 (based on 0.6MJ/m^2/nm @340 nm in the 89°C xenon arc) was:

0.53 months for the 89°C xenon arc;
1.13 months, the 63°C xenon arc;
6 months, Arizon UG;
ca. 24 months, Florida UG

For one color, the light yellow, deviation from this pattern was observed, showing a reversal with extensive color change in the 63°C xenon arc and Florida UG and with very little color change in the 89°C xenon arc and Arizon UG. This anomalous behavior can probably be attributed to temperature, resulting in a significant change in the bleaching and the yellowing reactions. It can be concluded that the 89°C xenon arc would be a proper choice for predicting Arizon UG; the 63°C xenon arc, Florida UG. The uniqueness of this color has demonstrated that care needs to be exercised in selecting appropriate accelerated testing methods to simulate and predict outdoor weathering performance.

UVCON™ (UVB) did not correlate with the above-mentioned devices, due to its peculiar spectral energy distribution vs. those of the filtered xenon arcs and sunlight. Therefore, UVCON is not recommended for predicting the outdoor service performance of materials which are wavelength sensitive.

A kinetic model was developed to facilitate the analysis of data and to illustrate the observed color change phenomena - initial bleaching followed by yellowing with subsequent bleaching.

EXTRUSION ADDITIVE INJECTION

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A recent technology available to today's extrusion market is the concept of on-line injection of additives directly into the extrusion process. The injection of additives into the extruder barrel is accomplished by an injection system containing a high pressure, precision metering gear pump.

With the increasing number of extrusion processes today that require the addition of some type of additive, this is a very timely development. Typical extrusion additives are: colorants, UV stabilizers, antioxidants, lubricants, tackifiers, and processing aids. These additives are available in a liquid form which can be successfully metered by a gear pump.

The theory of on-line additive injection involves metering the additives directly into the extrusion process, eliminating the precompounding step. Liquid additives may be injected directly into the process that produces the finished product. Two specific applications of this theory will be discussed: tackifier injection into a blown stretch film process and liquid colorant injection into a wire coating extrusion operation.

A number of benefits have been realized by extrusion processors employing this direct injection method. Some of these benefits which will be discussed in detail are: metering accuracy, versatility, quick changes in ratio, ease of handling and cost savings.

PROCESSABLE, ENVIRONMENTALLY STABLE, INSTRINSICALLY CONDUCTING POLYMERS

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In 1985, we reported the preparation of processable and environmentally stable polymeric compositions with conductivities ranging from 10^{-3}S/cm. to 5S/cm. by the electrochemical polymerization of pyrrole in the presence of suitable latexes. Concurrently, Polaroid announced the availability of a developmental poly-pyrrole/latex polymer complex, ICP-117, which can be dispersed in a number of common organic solvents and coated to give conductive films.

In this paper, we will report on the results of our coating studies with ICP-117, the physical properties of these films, their adhesion to various substrates and their effectiveness as humidity independent anti-stats. Also discussed will be our initial results with the thermal processibility of ICP-117 which includes compression and injection molding, extrusion and limited physical test data.

NEW POLYMERIC MATERIALS FOR USE IN ELECTRICAL APPLICATIONS

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Electrically conductive polymers are potentially useful for electronic devices and energy conversion systems. Chemically doped conductive polymers have been touted by many experts as having the potential to combine the conductivity of a metal with the light weight convenience of a plastic. However, the instability of chemically doped polymers introduces a serious problem for practical applications. In addition, the process of chemical doping is often hard to control, thus making industrial production of devices difficult.

Ion-implanted polymers represent a class of stable, conducting materials with properties that can be controlled by the implementation parameters. However, the conducting mechanism for ion-implanted polymers is more difficult to determine because of the physical damage associated with the implantation process.

In order to gain an insight into the mechanism of electrical conductivity in the ion-implanted polymers, Spire Corporation proposes a systematic approach to investigate the problem. The Phase I work was focused on the ion beam parameters, such as choice of ion species, ion dose and energy for obtaining reproducible changes of surface electrical properties. We have been successfully demonstrating the feasibility of creating a sheet resistivity of 1 to 10^6 mega-ohm per square on several substrates, such as Kapton, PPS, Lexan, Mylar, and G-10, by ion implantation. Phase II work will address the opportunity to study conduction mechanism in ion-implanted polymers, such as charge carrier lifetimes, densities, and mobilities, and explore the nature of implantation-induced defects, including crosslinking and scissions of polymer chains, double bonds, localized carrier and free radical formation.

This study is expected to show promising results and will lead to important contributions in the performance of the new generation of conducting polymers.

Anticipated Benefits/Potential Commercial Applications

Novel conducting polymers by ion implantation might lead to new ways to make junction devices, ultra-small electronic devices, semiconductor resists, and chemical sensors. The practical advantages would be appreciable in many important electronics, defense, construction and electrical applications.

PLASTICS, THE ENVIRONMENT AND A NEW FAMILY OF RUBBER/PLASTIC MACRO-BLENDS

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We are approaching an impending, enormous environmental crisis: essentially, what to do with the waste we create.

A unique and innovative method of separating discarded tires into their base components has been in development for over ten years. This method, now being commercialized, economically reduces tires to steel, synthetic fibers and reprocessable rubber.

Based on the success of this program, a new project was launched to determine ways to reintroduce this rubber back into the material stream, as opposed to disposing of it by questionable environmental methods such as burning the rubber as fuel.

Out of this research a new family of polymer alloys has been developed which addresses this concern by utilizing high percentages, up to 75%, of reclaimed rubber. The idea of using reclaimed rubber is an old one, but to date, resultant poor properties and economics have resulted in its lack of acceptance by plastics processors and plastics designers. This new material makes use of patent-pending innovative binder technologies which impart rubber-type properties into thermoplastics, thereby improving overall usefulness as opposed to acting as just a cost-reducing filler. Potential markets include automotive, agriculture, footwear, industrial and material handling.

This paper deals with the development of these newly commercialized materials, the environmental issues involved and the significant properties which will be of interest to designers and processors.

BIOPOLYMER APPLICATIONS OF MATERIALS

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A number of different biopolymers are under study for potential material applications. The first phase of the work involved the determination of the effects of culture and processing conditions on biopolymer yields and molecular weight distributions. The second phase is the evaluation of physical/chemical characteristics of these different molecular weights in order to match these properties with desired functions for end-product material applications.

The biopolymers under study are polysaccharide-based and include pullulan, chitosan, elsinan and levan. These biopolymers are synthesized by bacteria or fungi and then released into the external medium. Chitosan is cell wall bound. We have characterized some of these polymers in terms of the fermentation controls and processing/purification steps which influence the final yield and molecular weight distribution of the polymer product. We have cast films from different molecular weight distributions of some of these biopolymers and characterized these films for oxygen permeability, tensile strength and flexibility. The synthesis of a number of derivatives from some of these biopolymers is also under study in order to develop functional properties of interest.

Fiber formation from some of these polymers will be investigated during this year. In addition, cloning of key biosynthetic enzymes involved in the synthesis of some of the polymers is underway in order to improve production and simplify purification.

Material applications including new films for food packaging, fibers for textile and high performance fiber applications, binders for dyes and slow release such as fungicides, and reactive finishes for a variety of applications are areas under consideration for these biopolymers.

University

i	University of Lowell
ii	Massachusetts Institute of Technology
iii	Tufts University
iv	University of Massachusetts @ Amherst
v	Northeastern University
vi	Worcester Polytechnic Institute
vi	Southeastern Massachusetts University
vi	Boston University

ABSTRACTS

UNIVERSITY OF LOWELL

DEPARTMENT	TITLE OF ABSTRACT
Plastics Engineering	Overview of Plastics Engineering Department
	The Measurement of Thermal Diffusivity in a Flowing Polymer Melt
	Development of AI to Injection Molding
	Pressure Verification of a Computer Simulation Injection Mold Filling Software Package
	An Overview of Injection Molding Screw Technology
Chemistry	A Perspective of the Department of Chemistry at the University of Lowell
	Synthesis and Characterization of Copolysilanes
	Advanced Materials Based on Polymeric Liquid Crystals (PLC)
	Mesomorphic Properties of Polymers Copolymers and Model Compounds with Disiloxane and Diacetylenic Spacers
	Molecular Design Laboratory
	Investigation of Macromolecular Organization in a Class of Liquid Crystalline Polymers
Chemistry/PLastics	Fiber Processing of Linear Thermotropic Liquid Crystalline Polyesters
Chemistry/Physics	Thin Film Single Crystal Growth of Nonlinear Optical Macromolecular Systems

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THE DEPARTMENT OF PLASTICS ENGINEERING AT THE UNIVERSITY OF LOWELL

Nick R. Schott, Chairman
Department of Plastics Engineering, University of Lowell, Lowell, MA 01854

The Plastics Engineering Department at the University of Lowell is unique in th annals of Higher Education of the U.S. The department was foundeo in 1954 with th intent of training plastics engineering professionals for the industry o Massachusetts. Since then, the department has grown both on the undergraduate an graduate level with missions in both undergraduate training and graduate research The department presently consists of 15 full time faculty, 5 part time faculty, 22 undergraduate students and 150 graduate students (75 part time at night from loca industry). The department offers an ABET accredited B.S. degree in Plastic Engineering as well as an M.S. and Dr. of Engineering degree. A Ph.D. in Chemistr with an option in Polymer Science/Plastics Engineering is shared with the Chemistr Department. The department has over 1200 alumni and currently graduates 55 B.S. 35 M.S. and 5 Ph.D/Dr. Engineering students per year.

The department assures a well rounded B.S. program of study by interacting with a industrial advisory group and also by meeting the ABET (Accrediting Board fo Engineering and Technology) requirements. Currently, the B.S. program has th following content by subject area: Mathematics 11%, Basic Sciences 20% Engineering Sciences 28.5%, Engineering Design 16.8%, Humanities 17.5% and othe 6%. Other surveys of alumni show that 49 percent of the graduates go into researc and development, 40 percent go into manufacturing, 9 percent goes int marketing/sales and 2 percent goes into consulting. If one looks at the employer of our graduates one finds that 42% are in plastics processing, 32% are in th manufacture of end products, and 16% manufacture plastics materials. Two thirds o the graduates enter into the plastics field whereas the remainder goes into th allied fields of rubber, coatings, adhesives and fibers.

Since the start of the graduate program in 1967 the department has placed a increasing emphasis on funded research. Currently, the annual funding of researc exceeds $1 million per year. A breakdown is as follows: Processing $423,000 Physical Behavior $253,000, Materials $220,000, Computer Modeling $120,000 an other $73,000. The department has the best facilities of any university in th U.S in the area of plastics processing. The primary processes of injection molding single screw extrusion, blow molding and thermoforming are covered. The departmen also has excellent facilities in compounding including twin screw extrusion. Otne noteworthy facilities and equipment exist in the areas of chracterization an rheological measurements. Extensive Computer Hardward and Software is availabl for modeling, design and simulation. The funded research is coordinated throug the Plastics and Composites Development Center which is administered by th University of Lowell Research Foundation. It was founded in 1984 with the purpos of coordinating and strengthening research and development programs serving th plastics and composites industries.

The research interests and strengths of the faculty are in the areas of: plastic processing, composites designs and fabrication, polymer blends/modifications coatings and adhesives, characterization and performance, modeling and reactiv processing.

The department with its 35 years of existence and 1200 alumni has had a majo impact on the Massachusetts and the National Plastics Industry. Our alumn represent 5% of the 24,000 members of the Society of Plastics Engineers. Ou graduates are placed locally and nationwide. We also offer an M.S. degree a night, as well as industrial seminars either on campus or at industrial plant sites

THE MEASUREMENT OF THERMAL DIFFUSIVITY IN A FLOWING POLYMER MELT

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With the introduction of processing simulation programs, a large amount of accurate data is needed to correctly predict the molding behavior of a polymer material. One of the key properties needed to predict the heating and cooling characteristics of the plastic material is thermal diffusivity.

Thermal diffusivity is a measure of the amount and speed at which heat enters or leaves a material. Present day methods of measuring the thermal diffusivity involve measuring a temperature change of a stationary relaxed material. This is not representative of the effect on thermal properties of orientation created in a material during flow.

An experimental method was developed to take into consideration the effect of orientation induced upon the material while flowing. Material was extruded through a die. The die wall temperature was kept at a known constant and the temperature of the melt was measured when it entered and left the die. The differences between the temperatures and the speed at which the material moved through the die were then used to calculate the thermal diffusivity of the material.

DEVELOPMENT OF AN ARTIFICIAL INTELLIGENCE SYSTEM FOR INJECTION MOLDING

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The application of artificial intelligence (a real-time expert system) on plastics processing is intended to achieve the goal of on-line zero-defect molded parts. The knowledge of injection-molding processes and material characteristics is put in the form of rules which are capable of reasoning and making decision.

PICON (Process Intelligent CONtrol) is used as the real-time expert system tool for building the set of rules. Several types of rules (e.g., If-then, simulate, initialize and whenever rules) are used. Of these rules the IF-THEN rule is the most common type, which consists of the antecedent followed by a specified action.

When PICON runs, it tests the truth value of the antecedent. If this antecedent tests true, the action specified in the THEN portion of the rule is initiated. The hardward requirement involves the interfacing between the Lambda-plus mchine and injection molding machine. Lambda-plus machine is a parallel-processing computer with both a Lisp processor for expert system tasks and a MC68010 processor for high speed data acquisition. This presentation reports the progress of the project.

PRESSURE VERIFICATION OF A COMPUTER SIMULATION INJECTION MOLD FILLING SOFTWARE PACKAGE

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Computer simulation injection mold filling software packages are an invaluable tool for the design engineer. With today's "get it done yesterday" manufacturing attitude, an engineer must use every resource available to keep one step ahead of the competition.

One such software package will be analyzed for its reliability in today's molding world. Experimental verification of the analysis package will be performed by comparing the pressure drop occurring in a single cavity strip mold under actual molding conditions with that calculated by the software package.

This experimental data was compiled by equipping the mold with two pressure transducers in the runner system and three pressure transducers in the cavity itself. Also mounted with the transducers were thermocouples, one at each transducer for a total of five, so as to monitor the temperature at the same points where the pressure readings were being recorded. The injection molding machine used to do this molding was a 75-metric ton Battenfeld injection molding machine equipped with velocity control. The pressures and temperatures were recorded on a six channel Gould strip chart recorder. Other variables monitored were injection pressure, injection speed and melt temperature at the nozzle.

As noted earlier, this data will then be compared with the pressure drop calculated by the software package to determine how well the software package can preduct "real-life" molding conditions.

AN OVERVIEW OF INJECTION MOLDING SCREW TECHNOLOGY

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Injection molding is a cyclic process and, consequently, transient effects not present in continous processes as single screw extrusion have a profound influence on the performance of the reciprocating screw used for melt preparation.

This paper reviews these transient effects and indicates their importance in terms of familiar molding parameters such as cycle proportions and machine capacity utilization. Previously published experimental verification of these effects will be reviewed.

Injection molding screws are now beginning to incorporate design features to cope with these effects, which would otherwise limit screw performance. This paper reviews several new design concepts including extended mixing zones and indicates their benefits to the injection molder. Considering that gains in productivity can typically pay off in the space of a few weeks of operation, the cost of a replacement screw incorporating newer technology, these highly cost-effective solutions should be of major importance to Massachusetts molders.

A PERSPECTIVE OF THE DEPARTMENT OF CHEMISTRY AT THE UNIVERSITY OF LOWELL

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The Department of Chemistry at the University of Lowell is a growing department with strong research commitments and goals. The Department presently consists of 28 full-time faculty, 109 full-time graduate students and 20 part-time graduate students. Research activity in the areas of polymer science, biochemistry and analytical chemistry account for the majority of published and funded research activity. The Department has good instrumental capabilities which support these programs and has been steadily growing in capabilities.

The Polymer Science/Plastics Engineering Ph.D. program has been very successful, providing trained scientists and engineers at the Ph.D. level to industry for the past six years. The program is relatively unique in the country; students receive extensive training in both the fundamentals of macromolecular science and the engineering aspects of using such polymeric materials. The program consists of 9 full-time faculty members in the Department of Chemistry and 14 full-time faculty in the Plastics Engineering Department. The combined facilities of both departments allow for the preparation and characterization of unique materials from conception, e.g. molecular modeling, through evaluation of test specimens and even products, e.g. twin screw injection molding into a mold of our own computer aided design and manufacture. The present student enrollment of 65 full-time doctoral level students provides an exciting research environment for the students, faculty and professional staff.

The biochemistry program in the department is a joint effort between the departments of chemistry and biology. The chemistry department has 6 full-time faculty members and 3 part-time faculty members participating in wide ranging projects from the stop flow kinetic analysis of hemoglobin assembly to the analysis of the biochemical changes that occur within a cell at the onset of differentiation. The program includes work on the structure of nucleic acids, antibody production for utilization as molecular biology probes, the purification and modification of enzymes and the synthesis of small molecule probes for enzymatic activity. Available instrumentation includes a wide variety of analytical techniques and includes cell and tissue culture facilities. The faculty is involved in collaborative projects in the US and abroad and serves on both national and international committees.

The Analytical Division consisting of 4 full-time faculty and 12 doctoral students has expertise in chromatography and electrochemistry as well as atomic and molecular spectroscopy. Research interests of the analytical faculty cover the areas of capillary GC, HPLC, ICP, electroanalytical chemistry, flow injection analysis and fluorescence spectroscopy.

SYNTHESIS AND CHARACTERIZATION OF COPOLYSILANES

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Digital Equipment Corporation, Andover, MA. 01810

Polysilanes are receiving considerable interest for their use as self-developing photoresists, as precursors for silicon carbide fibers and, when doped, as electrical conductors. The many unique applications of these silicon backboned polymers are just becoming evident. Although a description of some silane polymers and copolymers have been reported, there is a clear need for the preparation and characterization of many more new polymers to evaluate structure-property relationships for these materials.

We have conducted studies on new silane copolymers containing varying amounts of either alkyl, cycloalkyl or aryl substituents. Copolymers have fractionated to yield narrow molecular weight samples to examine copolymer properties as a function of molecular weight. These copolymers have been characterized by techniques which include gel permeation chromatography, carbon-13 and silicon-29 nuclear magnetic resonance spectrometry, thermal characterization, light scattering, viscosity studies and determination of the rates of photodegradation.

This presentation will include a discussion on the synthesis and preparation of high molecular weight polymers. The fractionation of these highly polydisperse polymers to yield narrow molecular weight fractions will be presented. The relationship between copolymer molecular weight and composition will be addressed as it relates to some of the physical properties of the polymers including light scattering and solution viscometric results.

ADVANCED MATERIALS BASED ON POLYMERIC LIQUID CRYSTALS (PLC)

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Investigations in the field of polymeric liquid crystals (PLCs) are actively sustained by applications and potential applications in the areas of electro-optics, biomimetic and high-performance materials, as well as by the numerous fundamental questions associated with the behavior of PLCs.

In our laboratory we have carried out extensive research in two general areas: i) polymerization within liquid crystals, and ii) fundamental structure - property relations in PLCs (side-chain and main-chain).

Over the past few years, we have focused on investigation of thermotropic main chain PLCs based on alternating mesogens and flexible spacer groups (homo and copolymers, oligomers, models). Such structures combine the solubility and processability characteristics of conventional thermo-plastic materials with the unique rheological behavior and long-range order of liquid crystals. Development of advanced materials will hinge on control of orientational and conformational order of individual chains and control of extent and direction macroscopic alignment in the bulk sample.

An overview of our work will be presented with a focus on thermodynamic, NMR, X-ray and neutron scattering experiments as well as methods for producing alignment by external and flow fields. These flexible molecules can be fully extended by the nematic potential. Possible applications in the area of advanced composites are considered.

MESOMORPHIC PROPERTIES OF POLYMERS, COPOLYMERS AND MODEL COMPOUNDS WITH DISILOXANE AND DIACETYLENIC SPACERS

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Rigid rod-like liquid crystalline polymers have high transition temperatures which make melt-processing difficult.

Introduction of flexible spacers such a methylene, oxymethylene and siloxane between mesogenic moieties helps to reduce the transition temperatures of the polymers. Copolymerization also helps to reduce crystalline melting temperatures.

The object of this study is to investigate the effect of the introduction of flexible siloxane spacers on the mesogenic properties in homopolymers, copolymers and model compounds with different mesogenic groups. The homopolymers have been prepared by the condensation of mesogenic phenols such as 4,4'-dihydroxydiphenyl (I), 4,4'-dihydroxyazoxybenzene (II), 4,4'-dihydroxy (2,2'-dimethyl) azoxybenzene (III), 4,4'-dihydroxyphenylbenzoate (IV) with 10,12-bis(carboxypropyl) tetra-methyldisiloxane.

The copolymers have been prepared from the same mesogenic phenols and 10,12-docosadiyne-1,22-dioic acid and bis (carboxypropyl)-tetra-methyldisiloxane.

The model compounds have been prepared from 4-hydroxy-4'-methoxy-biphenyl (Ia), 4-hydroxy-4'-methoxyazoxybeneze (IIa), 4-hydroxy-4'-methoxy-(2,2'-dimethyl)azoxybenzene (IIIa) and 4-methoxy-4'-hydroxy-phenylbenzoate (IVa).

The compounds have been charachterized by elemental analysis, DSC, NMR and polarizing microscopy.

MOLECULAR DESIGN LABORATORY

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A Molecular Molding Laboratory has been set up in the Department of Chemistry at the University of Lowell. Molecular design research conducted in this laboratory coordinates with the ongoing experimental research on polymers with special optical and electronic properties, liquid crystalline polymers, and ionomers in the Polymer Science Program.

Currently, hardware includes (in the Department of Chemistry) a microVAX II networked with an Evans and Sutherland PS390 graphics terminal and various microcomputers and terminals. Also available for our studies is an Alliant FX/8. These computers are networked to the university-wide VAX cluster providing virtually unlimited computing power.

A variety of software packages are in use for the studies. The Chemlab II system from Molecular Design, Ltd. is an integrated package allowing, for example, for building of molecules, minimization of energy by quantum mechanics and molecular mechanics methods, determining the packaging of chains in crystalline polymers and calculation of electronic properties. Molecular dynamics calculations based on the forces between bonded as well as non-bonded atoms permits one to follow molecular and segmental motion. These calculations are part of a CHARMm package from Polygen, Inc. A Monte Carlo program has been loaded onto the Alliant computer. This can be used for problems such as the determination of packaging of ensembles of molecules. Thus, we have a fully integrated software set-up, hardware up to the minisupercomputer level in addition to an excellent graphics capability.

A variety of problems are currently under consideration. In one example, the electronic band structure in polyacetylene containing methylene defects in the otherwise conjugated chain is compared to that for the pristine polymer. Polyacetylene is the prototypical conducting polymer (by electronic mechanisms). Another type of conducting polymer is being studied: molecular dynamics methods will aid in the understanding of the mechanism by which polymers conduct through migration of ions. Calculations of molecular structures and packing of liquid crystalline polymers are new aspects of the strong program in liquid crystalline polymers at Lowell.

Details of these calculations will be presented in addition to a comprehensive description of the facility and its use format.

INVESTIGATION OF MACROMOLECULAR ORGANIZATION IN A CLASS OF LIQUID CRYSTALLINE POLYMERS

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Polygen, Inc.*

Conformational analysis and geometry determination, polymer chain packing and Monte Carlo simulation are presently being carried out on a novel series of liquid crystal polyethers at the University of Lowell Molecular Design Laboratory. These polymers have alternating stiff, mesogenic (liquid crystal forming) and flexible segments in the main chain. The first polyether series being studied maintains 4,4'-dihydroxy 2,2'-dimethyl azoxybenzene as the mesogenic unit with flexible spacers consisting of 7 to 10 methylene units.

The geometry of the molecules, determined by minimization of energy by quantum mechanics and molecular mechanics methods, uses the Chemlab II integrated software package on a microVAX II. A complete set of interatomic distances (bonded and non-bonded atoms), bond angles, and torsional angles thus become available, and the molecule can be studied on the Evans and Sutherland graphics terminal.

The above software system also provides for calculation of packing of polymer molecules on a crystalline lattice. This will provide a starting point for liquid crystal organization. However, for this less-ordered mesogenic state, Monte Carlo (on an Alliant FX/8 mini-supercomputer) and molecular dynamics methods (Polygen, Inc.) will consider organization and motion with parallel and anti-parallel organization of chains.

This research provides an additional component to the strong research program on the synthesis and characterization of liquid crystalline polymers under the direction of Prof. A. Blumstein. The modeling will aid in the choice of new structures to be synthesized for particular physical properties.

FIBER PROCESSING OF LINEAR THERMOTROPIC LIQUID CRYSTALLINE POLYESTERS

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The anisotropic properties of thermotropic liquid crystalline polymers are paramount to the development of highly oriented and extended polymer chains in a fiber spinning process. A single filament spinnerette is designed and built to accommodate small laboratory scale samples of thermotropic liquid crystalline polyesters to be spun from above the mesophase transition temperature. The geometry of the dies, the spinning temperature, pressure and the pick-up speed are the processing parameters which have been optimized to fit the requirements of spinning of different liquid crystalline polyesters and copolyesters.

Linear thermotropic liquid crystalline polyesters and copolyesters based on 4,4'-dihydroxy-2,2'-dimethyl-azoxybenzene and alkanedioic acids have been well studied by different techniques, and their conformational properties are well-established. The mechanical properties (i.e., tensile strength and tensile modulus) of fibers spun from these model polyesters are studied as a function of structural and operational parameters as a first step to the understanding of the chain extension process in the processing of fibers from relatively flexible thermotropic liquid crystal polyesters. Structural modifications are introduced into the flexible moiety and mesogenic group to reinforce the mechanical properties in the direction transversal to the fiber axis.

Phase diagrams are studied to optimize the composition of copolymers for fiber formation from the nematic mesophase.

THIN FILM SINGLE CRYSTAL GROWTH OF NONLINEAR OPTICAL MACROMOLECULAR SYSTEMS

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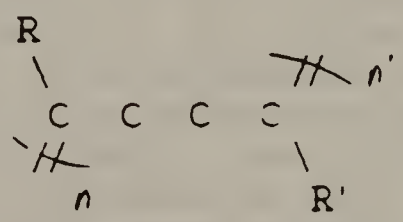
A class of polymers, the polydiacetylenes, has sparked much interest in their possible application as the active switching medium in an optical signal modulation scheme. These organic systems have been shown to possess subpicosecond response times and a high third order nonlinear susceptibility.

In order to take advantage of their unique optical properties, a well-ordered, optically flat, homogeneous and defect-free crystal must first be grown. The polydiacetylenes consist of a polymer backbone with a delocalized electronic structure to which suitable sidegroups (R,R') may be grafted as shown:



These moieties can be molecularly engineered to possess permanent dipole moments perpendicular to the backbone. Under the influence of an applied electrical field, the dipoles may be aligned.

To this end, we have designed and constructed a compact device that will allow the monomers with appropriate sidegroups to crystallize out of a saturated solution under a small temperature gradient while simultaneously aligning the molecules using a dc electric field.

On a dielectric substrate a pair of electrodes are deposited using photolithographic techniques. They are closely spaced together and will allow for a film thickness of about 2 microns and an optically useful length of 2.5 cm. The circular substrate is cushioned between two sets of O-rings which have a dual purpose. First, and more important, they allow a nylon vessel with a hole bored through it to restrict the solution containing the diacetylene to the area on the substrate where the electrodes have been deposited, and where orderly crystallization will occur. Second, the O-rings act to cushion the fragile substrate from compression forces originating during assemblage. On the reverse side of the substrate - the side opposite to the growth side - a thermo-electric cooler, flush with the substrate, will develop the desired thermal gradient across the growth point at the crystal solution interface.

The thin film grown in this manner will become one arm of a balanced Mach-Zehnder interferometer. Because of the delocalization of the electrons in the polydiacetylene backbone, we can expect a sub-picosecond response time with a modest power input in the 0.6 to 1.3 micron range.

An optically flat and organized crystalline structure is a necessary prerequisite for investigation of the relevant optical properties and the final possible application in devices. These characteristics will be assessed via optical and electron microscopy. The results of the investigation of the linear and nonlinear optical properties in these structures will be presented.

ABSTRACTS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

DEPARTMENT	TITLE OF ABSTRACT
Materials Science and Engineering	Formation and Characterization of Monolayer and Multilayer Thin Films of Electrically Conductive Surface Active Polyheterocycles
	The Effect of Processing History on Toughness in Polyamide Blends
	Mechanical and Optical Properties of a New Class of Diacetylene Containing Segmented Polyurethanes
	Poly(etheretherketone): Prototype for High Performance Semicrystalline Thermoplastics
	The Polymer Central Facility in MIT's Center for Materials Science and Engineering
	Rubber Modified Composites
Chemical Engineering	Effect of Micellar Morphology on Equilibrium Thermodynamic Properties of Micellar Solutions
	Research on Viscoelastic Fluid Mechanics
Chemical/Electrical Engineering	Water Purification by Electron Irradiation in the Presence of Polyethylene Oxide
Mechanical Engineering	Polymeric Matrices for Regeneration of Skin/Peripheral Nerve
Industry Polymer Processing Program	Research on the Processing of Polymer Based Composites

5170L/2/5280L/12-21

FORMATION AND CHARACTERIZATION OF MONOLAYER AND MULTILAYER THIN FILMS OF ELECTRICALLY CONDUCTIVE SURFACE ACTIVE POLYHETEROCYCLES

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We are currently exploring the possibility of utilizing the Langmuir-Blodgett (LB) film balance technique to fabricate monolayer and multilayer thin films of electrically conductive polymers. By introducing long hydrocarbon tail groups in the three position of pyrrole and thiophene heterocylic rings, we have found that it is possible to create surface active monomers and polymers that can be readily manipulated into monolayers via the LB technique.

Electrically conductive polymer monolayers can be created by reaction of the surface active monomers at the air-water interface of the LB trough with suitable oxidizing agents. Alternatively, the neutral surface active monomeric or polymeric forms of these materials can be directly manipulated into LB multilayers and subsequently chemically or electrochemically converted into electrically conducting polymer thin films comprised of conducting polymer chains separated from each other by insulating spacer groups as well-defined and controllable dimensions.

These thin films provide an ideal molecular organization for which to study the two-dimensional transport properties of conducting polymers. In addition, it is possible to fabricate organic superlattices by depositing the conducting polymer and a traditional insulating surface active molecule (such as stearic acid) in alternate layers, thus producing novel supermolecular organizations with electrical and optical properties unique to their molecular organization.

The synthesis, fabrication and properties of these new multilayer thin films will be discussed.

THE EFFECT OF PROCESSING HISTORY ON TOUGHNESS IN POLYAMIDE BLENDS

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Nylon, despite its ductility, has limited applications because of its low resistance to crack propagation. However, its toughness can be improved greatly by the addition of small, finely-dispersed rubber particles. The addition of the lower-modulus material lowers the tensile strength slightly, but it raises the impact strength significantly, making the toughened nylon more suitable for many uses.

It is thought that the toughening mechanism involves the surface-to-surface interparticle distance, the so-called ligament thickness. The polymer undergoes a brittle-ductile transition when this average interparticle distance is smaller than a critical value. During impact, if the ligament thickness is smaller than some critical value, the ligament will yield. If the ligament is thicker than this critical value, then the ligament will break instead of yielding. In any real material there will be a distribution of ligament thicknesses. If the number-average ligament thickness is smaller than the critical thickness, the yielding of the thin ones will dominate and will make the material tougher. In nylon, this transition can increase the impact strength by a factor of 4 or more.

The toughening effect of adding rubber particles can be enhanced by a number of factors, including a uniform rubber particle dispersion, resulting in a uniform ligament thickness, and good adhesion between the particle and the matrix, resulting in efficient stress transfer between the phases. However, it is difficult to retain the theoretically best blend characteristics with current processing techniques. The high temperatures used during processing promote degradation of the blend, and the high shear rates can cause gross segregation of the blend. The possible exposure of the nylon to water may reduce the matrix strength, while the possible exposure of the blend to oxygen may cause increased degradation. The variable exposure to these factors can disrupt the finely-tuned morphology and reduce the toughness of the two-phase blend.

Research into the effects of these processing parameters on the resin and the sensitivity of the resin to these parameters is being performed. Methods have been established for examining and characterizing the microstructure of the resin. The effect of temperature on the morphology is being examined by heating the resin for varying lengths of time at different temperatures. An effort is currently underway to use a full-scale injection molding machine to investigate the effects of such processing variables as the mold temperature and pressure, the cooling rate, the shear rate, and the oxygen and water content of the resin. The microstructure and the mechanical properties of the processed resin will be characterized, and relationships between the processing history, the morphology, and the toughness of rubber-toughened nylon blends will be established.

MECHANICAL AND OPTICAL PROPERTIES OF A NEW CLASS OF DIACETYLENE CONTAINING SEGMENTED POLYURETHANES

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In previous work, we have demonstrated that it is possible to dramatically modify the optical and thermal-mechanical properties of segmented polyurethanes by activating the solid state polymerization of diacetylene groups incorporated within the hard segments of these materials. During processing, the diacetylene groups remain dormant. However, upon exposure to radiation, these highly reactive groups are transformed into polydiacetylene chains which act to covalently link the hard segments together, thereby significantly increasing the cohesion and rigidity of the phase-separated hard domains.

This chemistry, therefore, provides an ideal method for the controlled crosslinking of the phase-separated hard segments allowing one the opportunity to systematically examine the influence of hard domain cohesion and rigidity on the mechanisms of deformation and relevant mechanical properties of these materials. In addition, since crosslinking occurs by the formation of conjugated polydiacetylene chains within the hard domains, the elastomers develop novel optical properties such as reversible thermochromism and mechanochromism. The latter phenomenon, which manifests itself as a reversible color change from blue to red during the appliation of a tensile strain, is unique to these new segmented polyurethanes.

In this presentation, we will describe the optical properties of these new materials and discuss how we have utilized the chemistry of the diacetylenes to study the mechanisms of deformation of these microphase separated copolymers.

POLY(ETHERETHERKETONE); PROTOTYPE FOR HIGH PERFORMANCE SEMICRYSTALLINE THERMOPLASTICS

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Poly(etheretherketone), PEEK, is an aromatic semicrystalline thermoplastic being used as the matrix material in high performance graphite-reinforced composites. Due to the relatively stiff backbone, PEEK shows excellent high temperature stability, with a glass transition of 145°C, melting point of 340°C, and continuous use temperature of 200°C.

In addition to excellent high temperature mechanical properties, PEEK is resistant to radiation and chemical attack. We have undertaken an extensive study into structure-property relationships in PEEK. Our aim is to gain insight into the effects of processing-induced crystalline morphology on ultimate properties, and thus provide processing guidelines for the use of semicrystalline thermoplastics in high performance applications.

One aspect of our research has been concerned with the effect of thermal history resulting from processing treatments on crystal size, number, and perfection. We will report results of annealing studies demonstrating that thermal treatment can cause chemical crosslinking in both neat resin and composite PEEK.

While high temperture annealing does increase the degree of crystallinity and perfection, fast cooling, such as that used in some processing treatments, can create internal stresses at the crystal-amorphous interface. A second aspect of research concerns effects of processing on tensile properties. Here we have shown that cooling rate dramatically affects the fracture stress for PEEK samples possessing the same degree of crystallinity. PEEK is a prototype, representing the first semi-crystalline high performance thermoplastic, and a new generation of PEEK-like polymers is under development. We hope that our results may be used as a starting point in generalization to the broader class of new semi-crystalline materials.

THE POLYMER CENTRAL FACILITY IN MIT'S CENTER FOR MATERIALS SCIENCE AND ENGINEERING

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Centralized facilities provide to the polymer community at MIT access to instrumentation which is cost-prohibitive to the individual researcher. The CMSE-sponsored polymer facility includes a 200 MHz NMR, a powerful FTIR, DSC and other thermal analysis equipment, several size exclusion chromatrographs including high temperature capabilities, ultramicrotomes, hood space and equipment for polymer synthesis.

We will outline the operation and management of this facility and will characterize some of the beneficial aspects of providing cohesion to a community of polymer researchers spread over many departments of MIT. Procedures for limited access by industrial users will be outlined.

RUBBER MODIFIED COMPOSITES

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Fiber reinforced plastic composites are prone to impact damage. Crosslinked epoxies and polyesters reinforced with continuous glass or graphite fibers crack internally under modest impacts; this reduces their other mechanical properties significantly. Tough thermoplastic matrices become embrittled when reinforced with fibers short enough to permit injection molding.

In both cases, thin rubber film coatings on the fibers can improve the situation: decrease impact damage or restore impact strength. The rubber must be crosslinked, be bonded to the fiber surface, interact with the composite matrix and be thin compared to the fiber diameter. If in the range of 50-1200 Angstroms, the impact improvements can be achieved without impairing the reinforcing action of the fibers. Materials used, methods of coating and the results in a variety of composites will be described.

EFFECT OF MICELLAR MORPHOLOGY ON EQUILIBRIUM THERMODYNAMIC PROPERTIES OF MICELLAR SOLUTIONS

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We have developed a theoretical framework capable of predicting self-consistently a wide spectrum of equilibrium thermodynamic properties of surfactant-water micellar solutions. The spectrum includes vapor pressure, osmotic pressure and osmotic compressibility, freezing temperature and specific heat.

We have shown that the magnitude of these thermodynamic properties and their dependence on solution conditions are strongly affected by the morphology, that is, shape and size, of the micellar aggregates present in solution. Consequently, by appropriately choosing surfactant molecular architecture, surfactant composition and solution conditions to tune micellar morphology, it may actually be possible to design and control the phase behavior of surfactant systems that are relevant to industrial and technological applications.

RESEARCH ON VISCOELASTIC FLUID MECHANICS

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This research program focuses on development of a quantitative understanding of the flow and stability of viscoelastic polymer melts and solutions through complex geometries such as occur in most polymer processing operations. It is the goal of this program to develop methods and techniques to model precisely the flow patterns in particular geometries. Classical, Newtonian methods do not work for viscoelastic fluids as has been well documented by the inability to calculate any high-elasticity viscoelastic flows despite many different approaches over the past 15 years. New numerical methods must be developed in order to avoid costly design errors in the development of processes for manufacturing polymers and also in order to develop adequate control strategies for these processes. Two key physical problems in viscoelastic flow must be solved to allow the objectives to be achieved. The first is the ability to calculate local, large stress (and velocity) variations that are unique to viscoelastic fluid; the second is the ability to predict the onset and nature of transitions in viscoelastic flows (at zero Reynolds number).

Our approach to solving these problems couples innovative finite element calculations with state-of-the-art laser doppler velocimetry and birefringence measurements. We have recently solved two critical problems in the numerical simulation of viscoelastic flows. First, we have developed a new formulation of the governing set of equations which makes explicit the elliptic character of the equation of motion. This explicitly elliptic momentum equation (EEME) formulation has provided the first stable convergent algorithm for the computation of viscoelastic flows, and is now being explored in several test geometries. Second, a proper method for treating viscoelastic stresses near singularities has been developed which allows convergence in problems with singularities.

The experiments are critical for elucidating the physics of flow transitions and the origin of locally large stress gradients. We have developed a 6-beam, 3-color laser Doppler velocimeter and a 2-color laser birefringence system for use in mapping local velocity and stress fields in viscoelastic flows as functions of the Deborah number. The Deboran number is the fundamental dimensionless group in non-Newtonian fluid mechanics, and it is defined as a ratio of a characteristic time for the polymer fluid to a characteristic time for the process flow. For flow tnrough a sudden contraction, De is defined by $\langle V_2 \rangle$ /R_2 where is a time constant for the polymeric fulid, R_2 is the radius of the downstream, small tube, and $\langle V_2 \rangle$ is the average velocity in the small tube. The LDV system we have studied flow through an axisymmetric sudden contraction and discovered a new flow transition from steady, two-dimensional flow to a time-periodic, three-dimensional flow. This transition appears to be an intermediate in the development of large toroidal vortices that are known to form upstream of the contraction at nigh De. Transitions such as the one described here can be critical to profitability of polymer processing operations.

WATER PURIFICATION BY ELECTRON IRRADIATION IN THE PRESENCE OF POLYETHYLNE OXIDE

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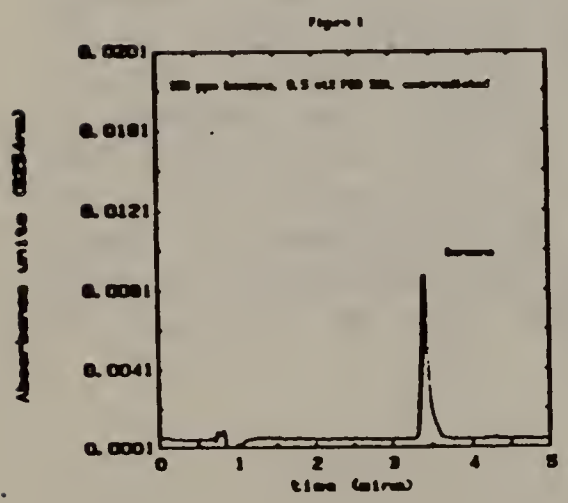
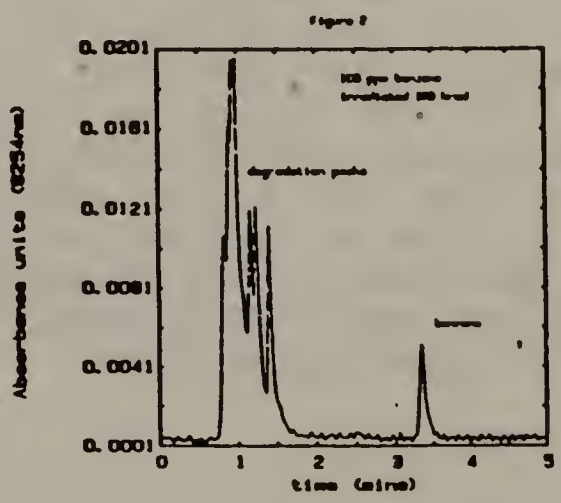
A method of water purification is being investigated whereby polymeric material is used as a scavenger for radical fragments formed from trace organic contaminants in water exposed to an electron beam.

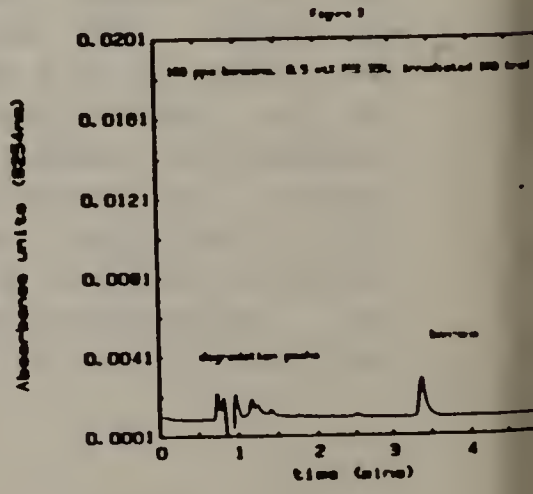
Previous work in this laboratory has shown that trace organic contaminants in water like polychlorobiphenyl (PCB) can be destroyed by electron irradiation of the water. More recently, the irradiation of benzene-water solutions has been investigated. Upon irradiation, benzene was destroyed and degradation products more polar than benzene appeared, as observed via reverse phase liquid chromatography (HPLC). Upon the addition of 0.5 weight percent polyethylene oxide (PEO) of molecular weight 35K to solution prior to irradiation, it was found that the number of previously observed degradation products peaks decreased; some peaks were reduced drastically and others disappeared completely. The following figures illustrate this effect.

Figure 1 is the chromatogram for an unirradiated solution of 100 ppm benezene and PEO, with the benzene peak shown eluting at 3.4 minutes. PEO does not absorb in the UV range. Figure 2 is the chromatogram for a solution of benzene alone which was irradiated with a dose of 100 krad. Irradiation decreased the benzene concentration by 43%. The more polar degradation products are shown eluting earlier than benzene. Figure 3 illustrates the effect of adding PEO to the benzene solution prior to irradiation. The degradation peaks have been drastically reduced by the addition of polymer.

It is supposed that the free radical species formed by the attack of hydroxyl radicals on the organic contaminants are coupled to radical sites formed on the dissolved polymer. Hence, decontamination of water may be expedited by adding polymer to solution prior to irradiation and then removing the polymer, for example by capture on sand particles if the polymer is PEO.







POLYMERIC MATRICES FOR REGENERATION OF SKIN AND PERIPHERAL NERVE

I.V. Yannas
Fibers and Polymers Laboratories, Massachusetts Institute of Technology

Certain collagen-glycosaminoglycan (CG) graft copolymers behaved as if they were a highly active and transient extracellular matrix (ECM) in a standard skin wound healing model. The copolymers were prepared as highly porous, biodegradable, crosslinked networks. Of the several polymers which were grafted onto the exposed muscle bed of the full-thickness skin wounds on guinea pigs only a few were capable of significantly delaying the kinetics of wound contraction before undergoing degradation.

When seeded with autologous, uncultured dermal cells, members of this group of biologically active CG copolymers were capable of diverting decisively the kinetics and mechanism of the wound healing process away from rapid contraction and scar synthesis towards arrest of contraction and synthesis of a dermis and an epidermis in an anatomically correct relation.

CG matrices possessed maximal biological activity when three criteria were simultaneously met: First, the mean diameter of pore channels of the CG copolymers ranged between the approximate limits 20 $\pm$ 4 um and 125 $\pm$ 35 um. Second, the rate at which the originally insoluble CG copolymers were degraded by collagenase did not exceed a relatively well-defined maximum limit in an *in vitro* assay. Third, CG copolymers which obeyed the above two criteria became capable of partial skin regeneration if they had been seeded with at least 5×10^4 dermal cells per cm^2 of graft area. These relatively specific requirements for a model ECM which induces regeneration of adult mammalian skin pose certain questions about the characteristics of physiological ECMs during development.

Other CG graft copolymers were capable of inducing regeneration of rat sciatic nerve across a 15-mm gap. The regenerated nerve was studied by electrophysiological procedures and a recovery of at least 50% of several indices (latency, conduction velocity, amplitude) was observed.

RESEARCH ON THE PROCESSING OF POLYMER-BASED COMPOSITES

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This paper will describe the ongoing research of the MIT-Industry Polymer Processing Program. A major focus of the program in recent years has been the processing of polymer-based composite materials with a major emphasis on thermoplastic materials and advanced composites applications.

Some recent research topics include:

1) the cost justification of automated composites fabrication equipment
2) the forming of thermoplastic composites
3) the bonding of thermoplastic composites
4) the manufacture of thermoplastic prepregs
5) the simulation of PMR-15/graphite composites molding
6) the behavior of epoxy based prepregs in automatic tape lay up; and
7) modeling of the filament winding process.

A brief overview of these research projects will be presented along with a discussion of the research objectives of the Program, with particular emphasis on its interaction with industry.

TUFTS UNIVERSITY

DEPARTMENT	TITLE OF ABSTRACT
Electrical Engineering	Physico-chemical Behavior of Photoactive Polymers Based on Novolac Resins and Diazonaphtoquinone Photosensitive Additives
Chemical Engineering	The Laboratory for Materials and Interfaces (LMI)- An Overview of the Research Activities
	Plasma Modified Carbon/Graphites Fibers for Advanced Composites
	Diffusion of Organic Vapors in Heterophase Polymer Membranes
	"The Incremental Draw Process" for Improved Fiber Products and Productivity
	Surface Modification of Synthetic Fibers for Elastomer Reinforcement
	Structure and Properties of Oriented Polymer Surfaces
	Vapor Sorption in Natural Rubber Samples of Varying Carbon Black Content

5170L/4/5280L/22-29

PHYSICO-CHEMICAL BEHAVIOR OF PHOTOACTIVE POLYMERS BASED ON NOVOLAC RESINS AND DIAZONAPTHOQUINONE PHOTOSENSITIVE ADDITIVES

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The key issue of modern opto-lithography is the resolution below 0.3 um. High performance photoactive polymeric materials and processes have made a major impact on advanced lithography over the past five years. Extensive study of the impact of structural details in novolac resin on lithographic performance is needed.

This paper reports some experimental data of structural change of a photosensitive polymeric material based on novalac resin and diazonapthoquinone photosensitive additives. Results are based on the measurements of permittivity of the resist solution. It is found tnat hydrogen bonding plays a major role in the development of lithographic performance.

Early report shows 1)that the performance of a photoactive material based on novolac resin and diazonapthoquinone additives can be increased by increasing the degree of ortho-bonding in the resin structure. Since elevated pre-baking temperature is detrimental for resist development, temperature-dependent photosensitivity of the material is also optimized.

THE LABORATORY FOR MATERIALS AND INTERFACES (LMI) AT TUFTS - AN OVERVIEW OF THE RESEARCH ACTIVITIES

N. Sung
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The Laboratory for Materials and Interfaces (LMI), established in 1986 within the college of engineering at Tufts, is an interdisciplinary laboratory to foster research on materials. Currently the LMI is focusing its activities on four different technology areas: polymers and composites, optical and electronic ceramics, suspensions and colloidal systems, and interface/adhesion science. An overview of the current and future activities at LMI will be presented with an emphasis on processing and characterization of polymeric and composite materials.

PLASMA-MODIFIED CARBON/GRAPHITES FIBERS FOR ADVANCED COMPOSITES

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Polyacrylonitrile (PAN) based graphite fibers were modified by plasma polymerization of three monomer gases. IR, ESCA and wetting angle studies indicate that the modified surface is highly cross-linked, highly polar and grafted onto the fiber surface.

Treated fibers exhibit a substantially higher interfacial bonding when tested in a single filament composite using epoxy and high temperature thermoplastic matrices. Also plasma treatments resulted in appreciably higher tensile strength of the fibers, suggesting that certain structural flaws may have been healed by plasma polymer coatings. This drastically differs for most commercial surface treatment processes which are detrimental to the tensile properties.

DIFFUSION OF ORGANIC VAPORS IN HETEROPHASE POLYMERS MEMBRANES

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N-hexane sorption in a composite membrane comprising glassy polystyrene (PS) microspheres dispersed in a rubber polybutadiene (PB) matrix was studied. Non-Fickian transport behavior attributed by earlier investigators to slow equilibration with PS/PB interphase regions is reexamined in the light of results demonstrating similar behavior in the absence of an interphase.

A model of vapor transport in glassy polymers is developed and incorporated into a model of transport in heterophase polymers in an attempt to stimulate experimental measurements of hexane uptake in PS/PB blends.

"THE INCREMENTAL DRAW PROCESS" FOR IMPROVED FIBER PRODUCTS AND PRODUCTIVITY

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Synthetic fibers and tapes such as those made from nylon, polyester, polypropylene and related polymers have to be drawn to achieve the properties that make them useful and commercially attractive.

The "Incremental Draw Process" is a major innovation in fiber drawing technology that allows both improved drawing productivity and unprecendented flexibility in control of the conditions of drawing. Fibers can be produced at high speeds and with improved physical properties, in particular, high tensile modulus. Drawing occurs on patented compact rolls in a large number of controlled increments that permit the draw temperature and the draw rate to change as the orientation of the fiber increases. Draw rates can be made magnitudes lower than conventional drawing without sacrificing productivity so that the process is of particular promise for polymers that are difficult to draw by conventional means.

The process is now in commercial use. Licensing for production or development facilities is available.

SURFACE MODIFICATION OF SYNTHETIC FIBERS FOR ELASTOMER REINFORCEMENT

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Reinforcing elastomers with synthetic fibers such as nylon and aramid fibers requires strong adhesion between the fiber and the elastomer matrix. Surfaces of the fibers and films are modified by plasma polymerization of butadiene to implant lightly cross-linked flexible chain polymers containing a high concentration of unsaturations.

The unsaturated moeities in grafted layer provide the reaction sites for covalent bonding with pre-vulcanized rubber during vulcanization. Solubility tests, IR spectroscopy and thermal analyses indicate that the structure of the grafted polymer layers varies depending on the plasma treatment conditions. Adhesion performance of treated surfaces with styrene-butadiene rubber was characterized by peel tests using nylon and kapton film as a substrate. Under optimum treatment conditions, modified surfaces exhibit strong adhesion resulting when tested in cohesive failure through elastomer matrix in peel tests. This contrasts to the untreated surfaces which register negligible amount of bonding.

STRUCTURE AND PROPERTIES OF ORIENTED POLYMER SURFACES

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Surfaces generated during uniaxial stretching of polymer films are substantially different from their unoriented counterparts. Changes in surface structure have been characterized by measuring molecular orientation and degree of crystallinity using FT-IR ATR dichroism technique. Surface properties, such as surface tension and friction coefficient, are studied by measuring contact angles and by single-stroke friction measurements.

Uniaxial drawing increases surface crystallinity and molecular orientation in both polypropylene (PP) and polyethyleneterephthalate (PET). This also leads to anisotropic friction coefficients when measured parallel and perpendicular to the drawing direction. On the other hand, contact angles measured with four different liquids exhibit anisotropy in oriented PP, but not in PET. The possible influence of anisotropic roughness in drawn PP on contact angle measurements is carefully examined.

VAPOR SORPTION IN NATURAL RUBBER SAMPLES OF VARYING CARBON BLACK CONTENT

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Incremental vapor sorption studies have been carried out with toluene in a series of laboratory compounded natural rubber samples to determine the effect of carbon black loading. The sorption isotherms, representing sorbed concentration versus vapor activity, obtained from loaded samples after adjusting for the weight fraction of carbon black, are equivalent within experimental error to non-reinforced rubber.

Sorption-time curves are Fickian at low concentrations but become sigmoidal at higher solvent concentrations and for liquid immersions, indicating the presence of relaxation effects. Apparent diffusion coefficients, which have been calculated from the half-time for sorption go through a maximum rather than increasing monotonically with concentration. These complications are important in understanding the contamination and permeation behavior of natural rubber.

ABSTRACTS

UNIVERSITY of MASSACHUSETTS @ AMHERST

DEPARTMENT	TITLE OF ABSTRACT
Polymer Science and Engineering	Graduate Program in PS&E
	High Resolution Imaging of Crystalline Polymers
	Synthesis of New Poly(Silarylene-Siloxane)s for Gas Separation Membranes
	New Fracture Mechanics Specimen: The Buckled Plate for composites
Mechanical Engineering	Microindentation Technique for Measuring Adhesion of Polymeric Films
	Computer Aided Design for Economical Injection Molding
	New Approach to Injection Molding Using Low Thermal Inertia Molding
Chemistry	A Quantitative Characterization Method for Foamed or Composite Polymeric Materials

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THE GRADUATE PROGRAM OF THE DEPARTMENT OF POLYMER SCIENCE AND ENGINEERING UNIVERSITY OF MASSACHUSETTS/AMHERST

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The Department of Polymer Science and Engineering at UMass is devoted to research and teaching of all aspects of polymers on the graduate and post graduate level. There are 13 full-time faculty, about 100 graduate students and approximately 56 post doctorates and visiting scientists. The department graduates approximately 15 Ph.D. students per year. In 1987, research expenditures were in excess of $7M with the faculty publishing 132 journal manuscripts.

The department is intimately connected with several on-campus polymer research organizations. The Materials Research Laboratory (MRL) is a NSF-supported facility which provides and maintains state-of-the-art research equipment and promotes interdisciplinary research in polymer materials with emphasis on research in liquid crystalline polymers, polymer interfaces and polymer-polymer blends.

Industrial research is focused in the Center for UMass-Industry Research on Polymers (CUMIRP). CUMIRP was originally seeded with monies from NSF and is now an entirely industry-supported program with 17 member companies. The main goal of CUMIRP is to carry out research in basic problems of polymer science and polymer engineering of long-range common interest to UMass faculty and industry. The strategy is to develop fundamental research in emerging areas of polymer technology relevant to industrial participants who could capitalize on the leads generated and incorporate them in their own in-house R&D efforts. The current research program of CUMIRP centers on model network polymers, composites, and functional polymers.

Additionally there are large research programs in Advanced Structural and Electrical Polymers (sponsored by the Department of Defense University Research Initiative) and the Institute of Interface Science (sponsored by IBM). Research facilities are valued at about $8M and include equipment for polymer characterization, morphology, rheology, and spectroscopy.

HIGH RESOLUTION IMAGING OF CRYSTALLINE POLYMERS

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Direct imaging of crystalline solids by High Resolution Electron Microscopy (HREM) has become an important tool for studying ultrastructures in inorganic materials systems, but its application to organic polymers has been limited by the problem of beam sensitivity. Careful use of low-dose procedures on a dedicated 200-kV JEOL 2000 FX has enabled us to obtain lattice resolution in a variety of polymeric solids. These methods are a natural complement to x-ray and electron scattering, and are more powerful than scattering in providing detailed information about the nature and relative orientation of defects. However, the physics of the image formation process may make a detailed interpretation of these images in terms of molecular architecture difficult. We present here results on polymer single crystals as well as lyotropic and thermotropic liquid crystals. We use both optical and digital image analysis to help us take full advantage of the limited information content of these images.

Poly(p-xylylene) [PPX] is a crystalline polymer which is used commercially as a barrier material in electronics applications because of its ability to be polymerized from the gaseous state as a conformal coating. We have grown single crystals of PPX from solutions in a-chloronapthalene and have been able to image well the [40.0] .44 nm planes. The optical diffractogram suggests that information transfer extends to the [80.0] .22 nm reflection. The lattice fringes extend over very large areas (500 nm) with no defects.

Poly(p-phenylene vinylene) [PPV] is a polymer with a completely conjugated backbone which has a conductivity up to 1000 ohm -1 cm -1 when properly doped with AsF5 or SbF5. The extent of order in the chain direction is expected to be particularly important in determining the electrical transport properties of this novel material. HREM studies have been able to reveal the .43 nm [110] equatorial spacing in small regions (5-8nm) which correspond in size to those seen by dark-field imaging using the equatorial reflection. Registration along the chain axis is revealed by reflections on the first layer line in the optical diffractogram.

HREM images of thermotropic liquid crystalline polymers [TLCP's] have confirmed the triclinic unit cell assigned to these systems. We have obtained images of both the [001] 2.9 nm spacing along the chain as well as the 0.60 [010] spacing between chains. The orientation and size of the fringes are dependent on processing conditions. Annealed samples exhibit fiber symmetry in which the orientation of the lattice fringes is consistent with a common orientation of the molecular trajector; quickly cast samples show many small regions of order indicative of quickly varying orientations of the polymer chains.

Poly p-phenylene benzobisthiazole) [PBZT] is a rigid-rod lyotropic liquid crystalline polymer which forms extremely stiff and high strength fibers (400 GPa modulus, 4 GPa tensile strength) when spun from solution. HREM images of the [010] 0.59 nm and [100] 0.36 nm spacings in PBZT have given support for a uniform twist grain boundary in which the molecules pass through the boundary by twisting and translating in such a way as to maintain constant flux. We have also been able to image PBZT lattice fringes within a mechanically induced "kink" band, and have thus begun to address morphologically the origins of the relatively low compressive strengths of these ultra-oriented systems.

SYNTHESIS OF NEW POLY(SILARYLENE-SILOXANE)S FOR GAS SEPARATION MEMBRANES

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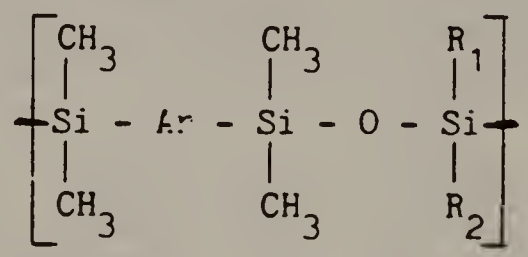
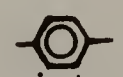
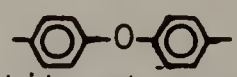
Silarylene-siloxane polymers were studied initially in our laboratory at the University of Massachusetts as candidates for high temperature elastomers because they can be designed to have very low glass transition temperatures in combination with excellent thermal stability. The polymers we prepared for this purpose may be represented by the following general structure:



in which Ar is principally  and  , and R_1 and R_2 are a wide variety of silane substituent groups. Very high molecular weight polymers of these types are prepared by the low temperature, step-growth polymerization of arylenedisilanol monomers with a bis-ureido silane in solution. Copolymerization with vinyl silane monomers provides a reactive unit for crosslinking, and the polymers with a very high content of vinyl silane units form an unusually high amount of residue at high temperatures.

Potential applications for this family of polymers, in addition to membranes for gas separation, include electron resist substrates, stationary phases for gas chromatography, high temperature and/or ablative elastomers, and, possibly, high temperature adhesive. Preliminary evaluations for several of these applications will be described, and the relationship between polymer composition (R_1 and R_2) and thermal properties will be discussed.

NEW FRACTURE MECHANICS SPECIMEN -THE BUCKLED PLATE-
FOR POLYMERS AND POLYMER COMPOSITES

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A new fracture mechanics specimen, the buckled plate (BP) specimen, with many attractive characteristics is being developed to measure the fracture properties of polymers and polymer composites. The most outstanding property of the BP specimen is that the crack driving force, G, is independent of the crack size. The mechanics of the specimen and experimental verification of the mechanics (slow crack growth in polyethylene (PE) and fracture toughness of polycarbonate (PC)/carbon fiber (CF) composites) will be discussed.

The increasing use of polymeric materials as load-bearing members in engineering structures requires not only the development of more durable materials, but also testing technology to evaluate appropriate properties. The BP specimen provides a test specimen that facilitates understanding fracture and fracture mechanisms so that a technological basis for reliable design of engineering structures and materials can be established.

Crack growth occurs because the energy released by crack growth, G, is equal or greater than the resistance of the material to crack growth. Analysis of the BP specimen shows that

$$G = \frac{\pi^2 E h^2}{12 \ell^2} (\ell - x)$$

where E is the modulus, h and P are the thickness and lengtn, respectively and x is the chord length of the buckled specimen. Thus, G is independent of crack size; a characteristic shared with only three other fracture mechanics specimens that are not useful for many polymeric materials.

Experimental verification of the mechanics analysis was obtained by studying the temperature dependence of Igepal-assisted slow crack growth in PE. The crack velocity at constant x was independent of the crack size; direct confirmation of the crack size independence of G. The rate of crack growth depended on G and temperature in general agreement with the literaturee.

Additional experimental verification was obtained by measuring the fracture toughness of PC/CF composites as a function of specimen geometry, but greatly affected by processing history.

MICROINDENTATION TECHNIQUE FOR MEASURING ADHESION OF POLYMERIC FILMS

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The lack of adhesion between a polymer coating and a rigid substrate represents one of the most common sources of failure in both process development and long-term reliability in the computer industry. A major research challenge is to accurately assess the adhesion of polymeric films. Ideally, the requirements of an adhesive test are: simple geometry, sensitivity and reliability, and quantitative interpretation of the results in terms of adhesive strength and interfacial fracture toughness. The objective of this research is to develop an adhesion test based on microindentation techniques. The test method involves the introduction of a mechanically stable crack into the interface by indenting the coating with either a small ball or Vickers indenter. The initiation of the crack and the resistance to crack propagation is then used as a measure of adhesive strength and interface toughness.

The adherence of polymide, epoxy, and acyrlic coatings to soda-lime glass were determined by the microindentation technique. The results demonstrate that the microindentation test yields a reliable and sensitive measure of strength and toughness of interfaces. Also, by virtue of its simplicity and small-scale, the microindentation test appears to meet most of the requirements for a widely applicable adhesion test.

COMPUTER-AIDED DESIGN FOR ECONOMICAL INJECTION MOLDING

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To improve producibility, parts must be designed for ease of manufacturing and assembly. Although design for assembly has received considerable attention, design for manufacturing has not. Parts are often designed without adequate consideration for the manufacturing costs. In order to reduce manufacturing costs it is necessary to focus attention at an early stage of design on factors that influence them. Experience has shown that for injection molding, designers usually select a design that will use the least amount of material. However, parts with minimum material are not always the lowest cost to manufacture. In addition to material costs, tooling and production costs must also be considered.

Research is currently underway to help address this problem. This research is proceeding in several phases. The first and current phase consists of data collection from collaborating companies. These data consist of tooling costs, cycle times, equipment operating costs and related information. These data are being analyzed to establish a database of relative cost and classification systems to relate part features (shape, size, tolerance, surface finish, material selection, etc.) to the collected data. Three classification systems for relative costs are being developed: one for tooling, one for operating, and one for materials.

The second phase of the research will develop simplified algorithms to provide a quantitative measure of molding difficulty by relating the cost to produce a part to the cost of producing a simple reference part. These algorithms will be used to develop a convenient means for designers who are not experts in injection molding to assess the relative cost of various alternate part designs.

The third stage of the research will involve converting these algorithms to software to be used on micro-computers. With this software, designers will be able to determine the relative cost of producing parts. The software will also provide alternate design suggestions along with their cost savings.

The purpose of this paper is to present the early results of this research.

NEW APPROACH TO INJECTION MOLDING USING LOW THERMAL INERTIA MOLDING

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A low thermal inertia injection molding concept has been applied to minimize flow-induced residual stresses in the molded part without increasing the total cycle time. This molding method uncouples the filling and cooling processes, which improves consistency of the part quality and eliminates the frozen-in "skin" layer. This molding process also reduces the temperature and the pressure required for the molding. Furthermore, the uncoupling allows independent control of the mold surface temperature. Details of the molding process and development of LTIM technology are discussed.

In particular, the variation of the length of filling with injection pressure and injection speed for the conventional cavity and LTIM cavity was investigated: the LTIM cavity filled completely at 162.5 psi which is the minimum injection pressure available whereas the conventional cavity required 6500 psi to fill completely. Moreoever, the LTIM cavity is completely filled at low injection speed of 0.95 inch/sec while the length of filling in the conventional cavity was 73% at the maximum injection speed of 5.61 inch/sec.

A QUANTITATIVE CHARACTERIZATION METHOD FOR FOAMED OR COMPOSITE POLYMERIC MATERIALS

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Characterization methods for foams and composites have traditionally relied on evaluating the performance of the polymeric material. Studies at the Chemistry Department's Optical Microscopy Laboratory have resulted in the development of quantitative characterization methods for polymeric foams and polymer composites based on the samples' inherent morphological features. These methods are equally applicable to measuring under static or dynamic conditions, hence can be employed as a straight forward procedure for characterizing and testing specific materials or as a control method to monitor processing conditions.

A distinct advantage in the use of these methods is the speed, ease, and simplicity by which measurements can be made. This is accomplished by the use of a computer which analyzes an image of the sample, then computes predetermined morphological parameters. The program continues to repeat sample measurements until statistically significant data have been collected.

The data acquisition mode is optional and ranges from fully automatic to fully manual. The computations are based on traditional stereological methods, ones by which a two-dimensional image is used to produce a three-dimensional characterization of the sample under investigation. The sample is viewed with either reflected or transmitted illumination, and the image with or without magnification is transmitted to the computer, such as an IBM AT or XT. At this time the image is adjusted electronically to provide maximum information most suitable for the subsequent image analysis and stereological parameter computations.

There is available an extensive selection of these parameters, including domain size, volume fraction, surface fraction, orientation, etc. These parameters can be an end in themselves functioning as test values for characterization. Or since the data resides in the computer, it is a simple matter to pursue correlation studies in which structure-property relationships can be established to determine the most significant morphological feature to enhance the thermal, mechanical or chemical performance of the polymeric system. This latter operation becomes the first step in molecular engineering in which modification of formulations and processing will enhance the most critical properties of polymer materials.

ABSTRACTS

NORTHEASTERN UNIVERSITY

Chemical Analysis and Materials Science	The Resource Facility for Increasing the Service Life of Plastics Processing Machinery
Chemistry	HPLC-Low Angle Laser Light Scattering (LALLS) and Linear Diode Array Spectroscopy of Alkaline Phosphatase Enzymes and Related Biopolymers
Chemical Engineering	Opportunities and Challenges in the Design of Implantable Biodegradable Polymeric Systems for the Delivery of Antimicrobial Agents and Vaccines

THE RESOURCE FACILITY FOR INCREASING THE SERVICE LIFE OF PLASTICS PROCESSING MACHINERY

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This facility carries out research and development work and information dissemination to support the Massachusetts plastics processing and processing machinery industry by improving the performance of critical parts in plastics processing machines using improved surface treatment technology. Stringent requirements for dimensional stability of dies, extrusion orifices, screws, etc., determine service life and are a major cost factor, especially for modern plastics with particulate additions.

This program is based on and further develops in-house expertise in alloy and surface treatment. Its current principal R & D project is to adapt and introduce the plasma nitriding (ion nitriding) technology into Massachusetts plastics processing practice, where it is currently not (or not substantially) in use. This process produces surfaces with high wear and corrosion resistance without affecting dimensional stability, and it has favorable economic and environmental characteristics.

In this program we are working closely with three Industrial Partners, General Electric Plastics Business Group, Pittsfield, MA.; Packaging Industries Group, Inc., Hyannis, MA.; and Composite Containers Corporation, Medford, MA. Using feedback from these partners, it is the goal of the program to establish the applicability and operating parameters of this process to plastics industry machine parts and to design and construct one or more new units adapted to and dedicated to plastics industry use.

Broadening this program, we will in the future create a resource data base and disseminate data on surface treatment technologies of interest to the plastics industry by means of workshops, hands-on training, and a newsletter, cooperating in the latter with existing channels of communication in the plastics industry. An important aspect of this program is the participation of an Industrial Advisory Board.

HPLC-LOW ANGLE LASER LIGHT SCATTERING (LALLS) AND LINEAR DIODE ARRAY SPECTROSCOPY ALKALINE PHOSPHATASE ENZYMES AND RELATED BIOPOLYMERS

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Low angle laser light scattering (LALLS) has long been utilized for molecular weig (M_w^{ave}) information related to organic polymers in HPLC or SEC. Unfortunatel its utilization and application for biopolymers has been much less reported, despi the obvious suggestions in the literature that this would be applicable under least some biopolymer HPLC conditions (e.g. SEC, isocratic HIC/RP, etc.) We ha been interested in developing a suitable HPLC-based assay for active and inacti alkaline phosphatase (AP) enzyme in milk and dairy products.

We have developed salt gradient HIC and RP (MeOH/HOH) approaches for both bovine a bacterial AP, as well as other proteins, using a combination of detecti approaches. These have included: LALLS, linear diode array spectroscopy (LDA on-line enzyme-substrate reactions (UV-VIS), and conventional fixed wavelength U Combinations of these detection approaches enable one to determine the relati amounts of active vs. inactive AP present in a given sample, and whether one dea with the bovine and/or bacterial forms. Though instrumentation-intensive, t overall results indicate a high degree of analyte specificity, the ability monitor for enzyme activity, on-line, and unambiguous enzyme determination via L and LALLS combined spectroscopies.

In the case of LDA detection, we have obtained the complete UV spectra for acti bovine and bacterial forms, shown these to be different, and have monitored for pe purity using both gradient elution RP and salt gradient elution HIC approache Though UV spectra at various elution points of each enzyme form/peak are simila the dual absorbance ratios are distinctly different throughout the eluting pea Plots of these ratios are not linear or horizontal, but rather mimic t chromatographic elution profile, suggesting a concentration dependent biopolym conformational equilibria during elution. We have now shown what is occurring the elution peak to cause the unusual dual ratio peak shapes observed.

LALLS measurements have confirmed the nature of the LDA phenomena as being due iso-MW species, rather than equilibria between aggregates, which was anoth possible explanation. In addition, LALLS has now been shown completely feasible a practical with salt gradient elution HIC approaches, for virtually all biopolyme that can be separated under normal HIC conditions. Isocratic SEC conditio interfaced with LALLS have shown the formation of dimers, as well higher aggregate under certain mobile phase conditions. The aggregates, as expected, are formed different degrees, dependent on the nature of the particular mobile phase us isocratically in SEC.

Finally, we have developed an on-line, enzyme-substrate detection system that can used together with LDA or fixed wavelength UV detection to indicate the amount active vs. inactive AP present in a given good product/sample. Typical applicatio of the above instrumental HPLC-detection approaches will be provided, often wi real world samples.

OPPORTUNITIES AND CHALLENGES IN THE DESIGN OF IMPLANTABLE BIODEGRADABLE POLYMERIC SYSTEMS FOR THE DELIVERY OF ANTIMICROBIAL AGENTS AND VACCINES

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An increasing number of implantable, biodegradable polymeric drug delivery systems are now in clinical use or undergoing experimental and clinical investigations for diverse therapeutic applications. This presentation summarizes the use of copolymers of lactic and glycolic acid as carrier materials for the controlled release of antigens for vaccination and of chemotherapeutic agents for the therapy of chronic microbial diseases.

These approaches illustrate some of the important conceptual and technical issues that must be considered in the future development of implantable biodegradable poylmeric systems. These systems offer considerable promise for achieving controlled release of the new classes of biological mediators produced by recombinant technology, particularly those vaccines intended for use in the Third World. The future development of these systems will almost certainly require the use of specialized approaches to particular delivery problems, but, overall, the development is viewed with considerable optimism.

UNIVERSITY	DEPARTMENT	TITLE OF ABSTRACT
Southeastern Massachusetts University	Electrical and Computer Eng	A Knowledge-based Expert System for Injection Molding Machine w a Certainty Factor
Boston University	Chemistry	Characterization of Marine Bioadhesive Proteins
Worcester Polytechnic Institute	Chemical Eng	The Development of Aqueous Size Exclusion Chromatography Study of Polysaccharide Characterization
	Mechanical Eng	Composite Process Applications

A KNOWLEDGE-BASED EXPERT SYSTEM FOR INJECTION MOLDING MACHINE WITH A CERTAINTY FACTOR*

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Expert systems can be very helpful in enhancing productivity as related to the manufacturing process. The expert system described in this paper has demonstrated the capability to assist an inexperienced operator to identify and to fix the defects in injection molding machine, so that the operator can utilize the best method to produce plastic products with optimum production efficiency.

The system called IMM makes use of a EMYCIN-like approach by employing forward and backward chaining strategies, certainty factor and well over one hundred rules. Both the certainty factor computation and knowledge representation are entirely new. The knowledge base of IMM consists of modules that cover ten stages of machine operations. The specific type of injection molding machine considered is plunger with a plunger preplasticizing machine. Details of system operations will be presented. The IMM expert system considered in this paper clearly shows the potential to use artificial intelligence methodology to signifiantly improve the productivity in plastic product industry.

* This paper is based on master's thesis work by Mr. Wang whose current address is 162 Smithfield Court, Basking Ridge, NJ. 07920.

CHARACTERIZATION OF MARINE BIOADHESIVES PROTEINS

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The objective of our research is to characterize the adhesive proteins used by marine organisms such as mussels and barnacles to attach themselves to rocks and other materials. Our immediate aim is to elucidate the amino acid sequences of these proteins via sequencing of the corresponding genes. We hope that the information learned from these studies can be used in the development of wet surface adhesives that may have medical and other applications.

The majority of our work has centered on adhesive proteins from various species of mussel. Many mussels attach themselves to rocks and other surface by means of a byssus, a thread-like, collagenous structure that terminates with a small disc, which is glued to the surface. The adhesive used for this purpose is a protein, which is secreted by the phenol gland in the foot of the mussel. Waite has shown that the adhesive protein from the blue mussel, Mytilus edulis contains substantial amounts of the decapeptide, Ala-Lys-Pro-Ser-Tyr-Hyp-Hyp-Thr-Dopa-Lys, and the hexapeptide, Ala-Lys-Pro-Thr-Dopa-Lys. This protein is unusual in having a very high percentage of hydroxylated amino acids, including 3- and 4-hydroxyproline (Hyp) and dihydroxyphenylalanine (Dopa), which may be important for the adhesion mechanism (by hydrogen bonding).

Using oligonucleotide probes corresponding to various regions of these sequences, we have isolated and sequenced several cDNA clones for the gene for this protein. This work shows that the adhesive protein consists primarily of variations on the decapeptide sequence

xx1-Lys-xx2-xx3-Tyr-Pro-Pro-Thr-Tyr-Lys

where xx1 is Pro, Ser or Ala, xx2 is quite variable, and xx3 is Thr or Ser. In some cases, the tetrapeptide xx3-Tyr-Pro-Pro is deleted, in confirmation of the published amino acid sequence data above. Sequencing of the full length cDNA is in progress.

Hybridization and preliminary sequence studies suggest that the adhesive proteins from the related mussels, Mytilus californianus, and Modiolus modiolus are similar to M. edulis, but that the protein from the ribbed mussel, Geukensia demissa, may be rather different. The latter protein contains large amounts of glycine and glutamic acid (or glutamine), which are completely absent from the other species.

Our goals are to discover how much diversity exists in adhesive proteins and to use this knowledge to develop new, special purpose adhesives that could be produced either by recombinant DNA technology or by chemical synthesis. We would also like to understand better the mechanisms of crosslinkage of these proteins and of surface bonding, and also how organisms clean or prepare the normally dirty surfaces to which they attach.

THE DEVELOPMENT OF AQUEOUS SIZE EXCLUSION CHROMATOGRAPHY STUDY OF POLYSACCHARIDE CHARACTERIZATION

J. Rollings
Chemical Engineering, Worcester Polytechnic Institute, Worcester, MA.

The heterogeneities in the polysaccharide branching component have signifiant influences on the physical chemical properties and enzyme depolymerization of these materials. In enzymatic depolymerization, the enzyme's and substrate's suspectibility greatly influence the rate, extent and pattern of the reaction.

The polysaccharide's branching structure is a primary factor that influences substrate susceptibility, From bulk chemical assays, one can only establish the average content of the polysacc-haride's linear and branching components. We have developed a combined size exclusion chromatographic (SEC)/low angle laser light scattering (LALLS) method capable of establishing polysaccharide branching as a function of the polymer's molecular weight.

The general experimental and theoretical developments will be discussed for this analytical method. Using this method, the amount of branching at each molecular weight of the biopolymer can be monitored during enzymatic depolymerization processes. In this presentation, the methods applicability using -amylase as a catalyst endo-attacked enzyme, but it is established that its action pattern is not completely random.

Non-random enzyme attack patterns shown in this work cannot be attributed solely to the enzyme. It is established here that the nature of the substrate as equally as important as the nature of the enzyme in determining kinetic parameters in starch depolymerization reactions.

COMPOSITE PROCESS APPLICATIONS

R. Richard
CAD Laboratory, Worcester Polytechnic Institute, Worcester, MA 01609

Fabrication is one-off prototype composite parts can be an prohibitively expensive. This problem further is compounded when the available labor force is undergraduate engineering students with little or no fabrication experience. However, the design and fabrication of composite prototypes can be a rewarding and successful activity for undergraduate design projects. This presentation will discuss the evolution of a low cost, relatively simple, method of designing and fabricating composite prototypes developed in conjunction with student design projects.

Since 1983 the author has been the faculty advisor for the design and fabrication of four composites off road vehicles. These vehicles competed in Mini Baja East, a student design contest sponsored by the Society of Automotive Engineers. One of the notable characteristics of most of the other Mini Baja entries is the extensive use of metal fabrication with very few entries making any use of structural composites.

The vehicles, designed under the authors guidance, made extensive use of stressed skinned composite monocoque structures. These vehicles were all six wheel drive skid-steering vehicles, and they were all designed and fabricated by students, who had little or no experience with composite design or fabrication before the project. All of the vehicles to date have been fabricated from Kevlar with various core materials including Airex foam, balsa, Nomex honeycomb and plywood.

The first vehicle (University of Lowell's KEVKAR) was designed using traditional drafting/design techniques. The top deck was formed as a wet lay-up utilizing a simple mold made from plywood paneling. The bottom was fabricated directly on a skeleton supporting the core material. The second body was far more sophisticated. Computer aided design techniques were used to define the geometry and scale templates. The female molds were produced from wood frames and skim coated plastered wall board surfaces. This technique proved to be an inexpensive and relatively simple means of producing a one off mold. The 1985 vehicle utilized the same basic body as the 84 vehicle, with most of the groups efforts focused on drive line issues.

In 1987, the most sophisticated vehicle, to date, was designed and fabricated by students at WPI. Computer aided design techniques were again utilized and mold fabrication was similar to the 1984 vehicle. The composite lay-up however, utilized epoxy pre-impregnated Kevlar and Nomex honey comb core material. The part was cured using standard vacuum bag techniques. Oven facilities were provided by Lindsay Ltd. of Gloucester, Massachusetts, a leader in high-tech sail boat design and fabrication. The resulting body weight only 35 lbs, one third of the lightest body produced by wet lay-up.

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University Matrices

-i- University of Lowell

Plastics Engineering
Chemistry
Chemical Engineering
Mechanical/Energy Engineering
Physics/Applied Physics/
Biological Sciences
Work Environment

-ii- University of Massachusetts/
Amherst

Polymer Science & Engineering
Chemistry
Mechanical Engineering
Biochemistry
Food Engineering/Forestry & WLP

-iii- Massachusetts Institute
of Technology

Program in Polymer Science/
Technology
Chemical Engineering
Industry Polymer Processing Program
Chemistry
Biology
Aeronautics/Astronautics
Civil/Mechanical Engineering
Electrical Engineering/Physics

-iv- Worcester Polytechnic Institute

Mechanical Engineering/
Material Sciences & Engineering/
Chemical Engineering
Firesafety Studies

-v- Tufts University

Lab for Materials/Interface
Electrical Engineering/
Mechanical Engineering/
Engineering Design

-vi- Northeastern University

Barnett Institute of Chemicals
& Materials Science
Mechanical Engineering/
Civil Engineering
Chemical Engineering

-vii- Brandeis University

Chemistry
Physics
Rosenstiel

-viii- Harvard University

Chemistry

-ix- Southeastern Massachusetts
University

Chemistry/
Electrical/Computer Engineering

-x- Boston University

Physics
Manufacturing Engineering

University of Lowell

Plastics Engineering

MCEC Topic	Faculty Subtopic	Arnold, E.	Chen, S.J.	Deanin, R.	Driscoll, S.	Grossman, S.	Huang, J.	Kyros, W.	Lai, F.	Malloy, R.
		Faculty Name								
Advanced Materials	Product Design			●	●					●
	Rheology		●		●					●
	Polymer Characterization			●	●	●	●			
	Polymer Chemistry			●	●	●	●			
	Material Testing			●	●	●	●	●		●
	Fibers/Composites	●		●				●		
	Polymerization Eng.		●	●		●	●			
	Synthesis			●		●	●			
Manufact./Processing/ Fabrication	Mold Design	●								●
	Reinforced Plastics	●						●		
	Injection Molding									●
	Extrusion									●
	Compounding			●	●	●	●			●
	CAD/CAE/CIM		●						●	●
	Machine Design									●
	In Plant Training				●	●	●			●
	Process Control		●						●	●
	Process Analysis/Models		●						●	●
	Process Indust./Economics		●	●	●					
Bio polymers	General Information			●		●	●			
Environment	Recycling Material		●		●	●				
	Packaging		●							

University of Lowell

Plastics Engineering

MCEC Topic	Faculty Subtopic	McCarthy, S.	Nunn, R.	Orroth, S.	Petrie, S.	Schott, N.	Tayebi, A.	Vasilos, T.
Advanced Materials	Product Design	●	●	●		●	●	
	Rheology	●	●			●		
	Polymer Characterization	●			●			
	Polymer Chemistry							
	Material Testing			●	●	●		●
	Fibers/Composites				●	●	●	●
	Polymerization Eng.	●			●		●	
	Synthesis							●
Manufact./Processing/ Fabrication	Mold Design	●	●	●		●		
	Reinforced Plastics		●		●	●		
	Injection Molding		●	●		●		
	Extrusion		●	●		●	●	
	Compounding			●		●	●	
	CAD/CAE/CIM	●	●	●		●		
	Machine Design		●					
	In Plant Training	●	●	●	●	●	●	
	Process Control		●	●		●		
	Process Analysis/Models	●	●	●		●		
	Process Indust./Economics		●	●		●	●	
Bio polymers	General Information							
Environment	Recycling Material							
	Packaging	●			●		●	

University of Lowell

Chemistry

MCEC Topic	Faculty Subtopic	Blumstein, A.	Blumstein, R.	Clough, S.	Israel, S.	Pyun, C.	Salamone, J.	Sawan, S.	Tripathy, S.	Watterson, A.
		Faculty Name								
Advanced Materials	Advanced Composites		●							
	Advanced Electronic Materials							●		
	Conducting Polymers			●					●	
	Design of Advanced Materials				●				●	●
	Functionalized Oligomers	●	●		●					
	Interface with Biological Systems								●	
	Ion Containing Polymers				●		●			●
	Ion Polymers				●		●			●
	Molecular Modeling			●				●		
	Molecular Weight Distribution Statistics					●				
	Nonlinear Optical Properties			●					●	
	Plasma Polymerization and Derivitization							●		
	Polymer Synthesis				●		●	●		●
	Polymeric Liquid Crystals	●	●							
	Rheology of Polymer Solutions						●	●		●
	Self Assembled Structures								●	
	Self Developing Photoresists							●		
	Sequence Distribution Statistics					●				●
	Thermal Stability and Decomposition				●					
Manufact./ Processing/ Fabrication	Langmuir Blodgett Films								●	
	Polymer Single Crystal Growth								●	
	Plasma Polymerization and Derivitization							●		
Biopolymers	Biocompatable Coatings							●		
	Biodegradable Coatings							●		
	Controlled Delivery Polymers							●		

University of Lowell

Chemical Engineering

MCEC Topic	Faculty Subtopic	Bonner, F.	Donatelli, A.	Eppler, R.	Flood, H.	Higgins, C.	Sama, D.	Slater, S.	Vasilos, T.	Walkinshaw, J.
Advanced Materials	PolyBlends/IPNS	●	●							
	Cellulostic	●				●				●
	Ceramics/Glasses	●		●					●	
	Fibers/Composites	●	●	●		●			●	●
	Sol-Gels	●								
	Coatings/Films	●		●		●				●
	Adhesion/Adhesives	●								
Manufact./Processing/ Fabrication	Nucleation/Aggregation	●								
	Surfactant Applications	●								
	Multi-Phase Polymerization	●								
	Cellulose Related	●				●				●
	Industrial Economic				●					
	Mfg./Process/Control							●		
	Appl. Thermodynamics						●			
Biopolymers	Enzyme Engineering	●								
	Micellar Solubization	●								
	Transport/Sys./Purification	●								
Environment	Appl. Thermal Dynam.						●			
	Energy Efficiency						●			
	Air Quality							●		

University of Lowell

Mechanical/Energy Engineering

MCEC Topic	Faculty Subtopic	Douglas, C.	Erturk, T.	O'Callahan, J.	Robertson, S.					
Advanced Materials	Product Design		●	●	●					
	Material Testing	●	●							
	Fibers/Composites	●	●							
Manufact./Processing/ Fabrication										
	Reinforced Plastics	●	●							
	CAD/CAE/CIM	●								
	Machine Design	●		●	●					
	Process Analysis/Models	●								

University of Lowell

Physics/Applied Physics
Biological Science*

MCEC Topic	Faculty Subtopic	Karakashian, A.	Broude, S.	Waldman, J.	*Wong, L.	*Eberiel, D.				
		Faculty Name								
Advanced Materials	Optical Polymer Characterization	●	●	●						
	Optical Polymer Devices	●	●							
Biopolymers										
	RNA Control of Synthesis				●					
Environment										
	Marine Coatings					●				

University of Lowell

Work Environment

MCEC Topic	Faculty Subtopic	Wegman, D.	Ellenbecker, M.	Punnett, L.						
		Faculty Name								
Advanced Materials	Toxicity Studies	●		●						
Manufact./Processing/ Fabrication										
	Exhaust Ventilation		●							
	Ergonomic Design			●						
Environment										
	Health Effects	●		●						
	Source Reduction		●							
	Incineration Technology		●							

University of Massachusetts
Amherst

Polymer Science/Engineering

MCEC Topic	Faculty Subtopic	Chien, J.	Farris, R.	Hoagland, D.	Hsu, S.	Kantor, S.	Lenz, R.	MacKnight, W.	McCarthy, T.	Muthukumar, M
Advanced Materials	Synthesis	●				●	●		●	
	Catalysts	●					●			
	Mechanical Properties		●	●	●			●		
	Composites/Blends		●		●		●	●		
	Piezoelectric Polymers				●					
	Liquid Cryst. Polymers		●		●	●	●			
	Conducting Polymers	●					●			
	Optical Properties			●						
Manufact. /Processing/ Fabrication	Fiber Spinning		●							
	Rheology		●	●			●			
	Aggregation/Diffusion			●						●
	Artificial Intelligence									
Biopolymers	Enzymes	●								
	Biomedical Polymers	●					●			
	Polymer-Cell Inter.									
	Biotech. Methods						●			
Environment	Polymer Degradation	●								
	Flame Retardation	●								
	Stabilization	●								

University of Massachusetts
Amherst

Polymer Science/Engineering

MCEC Topic	Faculty Subtopic	Porter, R.	Stein, R.	Thomas, E.	Tirrell, D.	Karasz, F.				
Advanced Materials	Synthesis				●					
	Catalysts									
	Mechanical Properties	●	●	●						
	Composites/Blends	●	●	●		●				
	Piezoelectric Polymers		●							
	Liquid Cryst. Polymers	●	●	●						
	Conducting Polymers					●				
	Optical Properties		●							
Manufact. /Processing/ Fabrication	Fiber Spinning			●						
	Rheology	●	●							
	Aggregation/Diffusion			●						
	Artificial Intelligence					●				
Biopolymers	Enzymes									
	Biomedical Polymers				●					
	Polymer-Cell Inter.				●					
	Biotech. Methods				●					
Environment	Polymer Degradation	●				●				
	Flame Retardation	●				●				
	Stabilization	●				●				

University of Massachusetts
Amherst

Chemistry Department

MCEC Topic	Faculty Subtopic	Lahti, P.	Rowell, R.	Archer, R.	Rhodes, M.	Lillya, P.	...	...	....	
		Faculty Name								
Advanced Materials	Semiconductor Polymers	●								
	Organic Ferromagnets	●								
	Optical Info. Storage in Organic Materials	●								
	Association Polymers		●							
	Develop. of Test. Methods for Structure Prop. Correl.				●					
	Liquid Crystalline Polymers					●				
	High Modulus Materials					●				
	Thermoplastic Elastomers					●				
	Telechelic Stars					●				
	Discotic Liquid Crystalline Polymers					●				
	Supersensitive Resists			●						
	Strong Adhesives			●						
	Conducting Polymers			●						
Manufact./Processing/ Fabrication										
	Low Viscosity Nematic Melts					●				
	Character. of Structure Formation during Processing				●					

University of Massachusetts
Amherst

Mechanical Engineering

MCEC Topic	Faculty Subtopic	Sunderland, J.	Poli, C.	Donovan, J.	Kim, B.	Dixon, J.	Graves, RJ			
Advanced Materials	Fracture			●	●					
	Fatigue			●	●					
	Creep				●					
	Microstructure			●						
	Environment Assist. Slow Crack Growth			●						
	Wear			●						
Manufact./Processing/ Fabrication	Injection Molding				●					
	Compression Molding				●					
	Blow Molding				●					
	Thermo-forming				●					
	Design		●				●			
	Heat Transfer in Injection Molding	●								
	Design Modifications to Improve Productivity	●								
	Computer Predictions of Cycle Time	●								
	Computer Aided Design					●	●			
	Computer Aided Mfg.					●				
	Computer Integrated Mfg.					●	●			
	Automation					●	●			
	Tool and Die Design					●				
	Automated Die Design					●				
	Artificial Intelligence					●				

University of Massachusetts
Amherst

Biochemistry

MCEC Topic	Faculty Subtopic	Fournier, M.	Fuller, R.	Mason, T.						
Biopolymers	Protein Engineering	●		●						
	Polyhydroxyalkanoates		●							
	Biodegradable Materials		●							

University of Massachusetts
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Food Engineering Dept
Forestry & WLM Dept*

MCEC Topic	Faculty Subtopic	Smulski, S.	Peleg, M.							
		Faculty Name								
Advanced Materials	Wood/Polymer Composites	●								
Biopolymers										
	Textural fruit products		●							
	Application to biopolymers		●							
Environment										
	Waste plastics as property modifiers	●								

Massachusetts Institute of Technology

Program in Polymer Science and Technology
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MCEC Topic	Faculty Subtopic	Suh, N.	Suter, U.	Tanaka, T.	Williams, J.					
		Faculty Name								
Advanced Materials	Product Design	●								
	Polymer Characterization			●						
	Material Testing	●			●					
	Fibers/Composites				●					
	Synthesis		●							
	NDE				●					
	Theory		●							
Manufact./ Processing/ Fabrication	Reinforced Plastics	●								
	Injection Molding	●								
	Mold Design	●								
	CAD/CAE/CIM	●								
	Machine Design	●								
	Process Analysis/Models	●								
	Process Indust./Economics									
Biopolymers	Lens Proteins			●						
	Actin Gells			●						
	Cell Differentiation			●						

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Program in Polymer Science and Technology
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MCEC Topic	Faculty Subtopic	Argon, A.	Armstrong, R.	Backer, S.	Benedek, G.	Blankschtein, D.	Boyce, M.	Cohen, Robert	Cohen, Richard
		Faculty Name							
Advanced Materials	Product Design			●					
	Rheology	●		●					
	Polymer Characterization								●
	Material Testing	●		●			●		
	Fibers/Composites	●	●	●					
	Synthesis							●	
	Morphology							●	
	Mechanical Properties		●					●	
	Theory					●			
	Surface/Interfacts							●	
	Viscoelasticity		●					●	
Manufact./ Processing/ Fabrication	Extrusion						●		
	CAD/CAE/CIM						●		
	Process Control			●					
	Process Analysis/Models			●			●		
	Process Indust./Economics								
	Rheology Expts.		●						
	Finite Elements		●						
Biopolymers	General								●
	Miscelles					●			
	Theory					●			
	Micelles & Microemulsion				●				
	Biologic Macromolecules				●				

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Program in Polymer Science and Technology
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MCEC Topic	Faculty Subtopic	Selby	Langer	Roylance, D	Wrighton	Yannas, I.				
		Faculty Name								
Advanced Materials	Product Design		●	●						
	Rheology			●		●				
	Polymer Characterization		●	●		●				
	Polymer Chemistry	●	●	●		●				
	Material Testing		●	●						
	Fibers/Composites			●						
	Polymerization Engineering		●	●						
	Synthesis	●	●		●					
	Redox Polymers				●					
Manufact./ Processing/ Fabrication	Mold Design			●						
	Reinforced Plastics			●						
	Injection Molding			●						
	Extrusion			●						
	CAD/CAE/CIM			●						
	In Plant Training			●						
	Process Control			●						
	Process Analysis/Models			●						
	Process Indust./Economics			●						
Biopolymers	General Information					●				
	Synthesis					●				
	Structures/Properties					●				
	Tissue Interaction					●				
Environment	Packaging			●						

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Program in Polymer Science and Technology
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MCEC Topic	Faculty Subtopic	Dresselhau, M.	Gutowski, T.	McGarry, F.	Merrill, E.	Rha, C.	Rubner, M.	Senturia, S.	Seyferth, D.	
		Faculty Name								
Advanced Materials	Product Design			●		●				
	Rheology					●			●	
	Polymer Characterization			●		●		●	●	
	Polymer Chemistry								●	
	Material Testing			●		●		●	●	
	Fibers/Composites	●	●	●			●	●	●	
	Polymerization Engineering								●	
	Synthesis				●		●		●	
	Mechanical Properties						●			
	Surface/Interfacts				●					
	Optical Properties						●			
	Electrical Properties						●			
	Polymeric Thin Film						●			
	New Fibers						●			
Manufact./ Processing/ Fabrication	Reinforced Plastics		●	●						
	Extrusion					●				
	Process Control					●				
	Process Analysis/Models		●							
	Process Indust./Economics		●							
	Rheology Expts.				●					
	Extensional Flow				●					
	Post Fabrication Processing						●			
Biopolymers	Composites Processing		●							
	Design & Engineering					●				
	Functional Applications					●				
	Biomedical				●	●				
	Solution Properties					●				
	Biopolymer Separations				●					
Environment	Polymers in Microelectronics							●		
	Moisture in Polymers							●		
	Mechnical Properties of Polymer Films							●		

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Chemical Engineering
Program in Polymer Science & Engineering

MCEC Topic	Faculty Subtopic	Cohen, R.	Merrill, E.	Suter, U.	Armstrong, R.	Blankschtein, D.				
		Faculty Name								
Advanced Materials	Synthesis	●	●	●						
	Morphology	●								
	Mechanical Props.	●			●					
	Composites				●					
	Theory			●		●				
	Surfaces/Interfaces	●	●							
	Viscoelasticity	●			●					
Manufact./ Processing/ Fabrication										
	Rheology Expts.		●		●					
	Finite Elements				●					
	Non Isoinermal Flow									
	Theory									
	Extension Flow		●							
Biopolymers	Micelles					●				
	Theory					●				
	Biomedical Polymers		●							
	Biopolymer Separations		●							

Massachusetts Institute
of Technology

Industry Polymer Processing
Program

MCEC Topic	Faculty Subtopic	Armstrong, R.	Clark, J.	Gutowski, T.	Latanison, R.	Roylance, D.	Suh, N.	Tse, M.		
Advanced Materials	Polymer Foams						●			
	Composite Interface			●		●				
	Polymer Alloys					●	●			
	IPN's						●			
	Rheology	●								
	Reaction Kinetics					●		●		
Manufact./ Processing/ Fabrication										
	Cost		●	●						
	Auto. Equip. Just.			●						
	Consolidation			●						
	Forming			●			●			
	Pultrusion			●		●		●		
	Cure Control			●		●		●		
	Fiber Impregnation			●				●		
	Tape Layup/Winding			●						
	NDE						●	●		
	Bonding T.P. Comp.			●						
	Process Simulation	●		●		●	●	●		
Environment										
	Graphite/Metal Cor.				●					

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Chemistry

MCEC Topic	Faculty Subtopic	Silbey, R.	Schrock, R.	Buchwald, S.	Wrighton, M.	Seyferth, D.				
		Faculty Name								
Advanced Materials	Preceramic Polymers					●				
	Catalytic Syntheses		●							
	Organic Synthesis			●						
	Redox Polymers				●					
	Theory	●								
	Conducting Polymers	●	●		●					
	Non-linear Optical Properties	●	●							

Massachusetts Institute
of Technology

Biology

Faculty Name

MCEC Topic	Faculty Subtopic	Hynes, R.	Khorana, H.	King, J.	Kim, P.	Matsudaira, P.	RajBhandary, UL	Rich, A.	Robbins, P.	Solomon, F.
Biopolymers										
	Proteins	●	●	●	●	●		●		●
	Nucleric Acids						●	●		
	Polysaccharides								●	

Faculty Name

MCEC Topic	Faculty Subtopic	Rosenberg, R.	Sauer, R.	Schimmel, P.	Varshavsky, A.
Biopolymers					
	Proteins	●	●	●	●
	Nucleric Acids		●	●	●
	Polysaccharides				

Massachusetts Institute of Technology

Aeronautics/Astronautics

Faculty Name

MCEC Topic	Faculty Subtopic	Lagace, P.	Mar, J.	Dugundji, J.	Witmer, E.					
Advanced Materials	Fracture	●								
	Damage Tolerace	●	●							
	Fatigue	●								
	Dynamic Properties			●						
	Impact Resistance	●	●	●	●					
	Structural Properties	●	●	●						
	Test Procedures	●								

Massachusetts Institute of of Technology

Civil/Mechanical
Physics/Electrical Eng*

MCEC Topic	Faculty Subtopic	Backer, S.	Li, V.	*Dresselhaus, M.						
Advanced Materials	Polymer Fiber	●								
	PRF Composites	●	●							
	Composite Fracture Mechanics		●							
	Carbon Fibers/ Composites			●						
Manufact./Processing/ Fabrication										
	Polymer Fiber	●								
	Fibrous Structures	●								

Worcester Polytechnic Institute

Mechanical Engineering
Material Science/Engineering

Faculty Name

MCEC Topic	Faculty Subtopic	Gordon, B.	Leatherman, G.	Tuler, F.	Bar-On, I.	Salgal, S.	Biederman, R.			
Advanced Materials	Product Design	●			●					
	Materials Testing	●		●	●					
	Polymer Characterization		●				●			
	Fibers/Composites	●	●	●						
Manufact./Processing/ Fabrication										
	Reinforced Plastics	●								
	Injection Molding	●								
	CAD/CAE					●				
Environment										
	Packaging/Electronic	●	●		●					

Worcester Polytecnic Institute

Chemical Engineering

MCEC Topic	Faculty Subtopic	Dixon, A.	Clark W.	Rollings, J.	Weiss, A.	Ma, Y.				
		Faculty Name								
Advanced Materials	Reactor Modelling	●				●				
	Novel Reactors			●						
Manufact./ Processing/ Fabrication	Novel Reactors			●						
	Inorganic Membranes					●				
Biopolymers	Characterization		●	●						
	Thermodynamic Properties		●	●						
	Structure/Function			●						
	Kinetic Studies			●						
	Novel Reactors for Prop.			●						
	New Characterization Methods			●						
Environment	Membrane Separations		●	●	●	●				
	Combined Reactor/Separators			●						
	Recycling				●					
	Waste Disposal				●					
	Air Purification				●					
	Membrane Reactors				●	●				

Worcester Polytechnic Institute

Firesafety Studies

MCEC Topic	Faculty Subtopic	Lucht, D.	Custer, R.	Beyler, C.	Barnett, J.	Titus, J.				
Advanced Materials	Identification-appropriate fire test procedures	●	●	●		●				
	Measurement-ignition properties		●	●						
	Measurement-flammability properties		●	●						
	Modeling-ignition phenomena			●	●	●				
Manufact./Processing/ Fabrication										
	Modeling-process fire hazards	●		●	●	●				
	Modeling-process toxcity hazards			●						
Environment										
	Feasibility studies-polymer incineration	●		●		●				
	Quantification-polymer products of combustion			●						
	Modeling-toxic hazards of combustion products			●						

Tufts University

Laboratory for Materials/Interface

MCEC Topic	Faculty Subtopic	Sung, N.	Ryder, D.	Sussman, M.	Meldon, J.	Botsaris, G.				
		Faculty Name								
Advanced Materials	Fiber Reinforced Composite	●								
	Membrane Science	●			●					
	Optical Polymers	●	●							
	Org./Inorg. Molecular Composites	●	●							
	Surface Science					●				
Manufact./Processing/ Fabrication										
	Molecular Sensor for Cure Monitoring	●								
	Fiber Processing			●						
	Plasma Treatment	●								
	Surface Modification	●								
Biopolymers										
	Cell Culture Substrate			●						

Tufts University

Electrical Engineering Dept
Mechanical Engineering Dept*
Engineering Design**

MCEC Topic	Faculty Subtopic	Gupta, T.	* Saigal, A.	** Chern, S.	** Crochetiere, W.					
		Faculty Name								
Advanced Materials	Characterization	●								
	Applications	●								
	Materials Testing		●							
Manufact./Processing/ Fabrication										
	Monolithic Integrated Circuits	●								
	Thick-Thin Film Hybrid Circuits	●								
	Mold Design			●						
	CAD/CAM/CAE			●						
	Automation				●					
	Machine Design				●					

Northeastern University

Barnett Institute of Chemical Analysis/ Materials Science

MCEC Topic	Faculty Subtopic	Blucher, J.	Giese, R.	Giessen, W.	Karger, B.	Krull, I.				
		Faculty Name								
Advanced Materials	Synthesis of Polymeric Reagents					●				
Manufact./Processing/ Fabrication										
	Improved Process. Equip. via Surface Modification	●		●						
	Characterization					●				
Biopolymers										
	Detection/Analysis		●		●	●				
	Separation				●	●				
	Characterization		●							

Northeastern University

Mechanical Engineering
Civil Engineering*

MCEC Topic	Faculty Subtopic	Nowak, W.	Blucher, J.	*King, P.	*Blanc, F.					
Advanced Materials	Coatings for polymers (sheets, fibers)	●								
Manufact./Processing/ Fabrication										
	Surface Treatments of Machinery Parts		●							
Environment										
	Sludge Conditioning			●						
	Primary Coagulants			●						
	Polymer Applications to Industrial Waste Treatment				●					

Northeastern University

Chemical Engineering

MCEC Topic	Faculty Subtopic	Faculty Name: Wise, D.
Biopolymers		
	Biodegradable Polymers	●
	Structural Biopolymers	●
	Bone Repair Implants	●
	Electrically-Conducting Biopolymers	●
Environment		
	Controlled Release Herbicides	●
	Bioremenation Applications	●

Brandeis University

Chemistry Dept

MCEC Topic	Faculty Subtopic	Epstein, I.	Herzfeld, J.	Jordan, P.	Foxman, B.	Rosenblum, M.				
Advanced Materials	Non-linear Optical Materials				●					
	Low Dimensional Materials					●				
Biopolymers										
	Binding Kinetics	●								
	Polymerizing Proteins		●							
	Micellar Systems		●							
	Membranes			●						

Brandeis University

Physics Dept

Faculty Name

MCEC Topic	Faculty Subtopic	Meyer, R.	Sneddon, L.	Berko, S.	Canter, K	Odagaki, T.	Oldenbourg, R.	Redfield, A.		
Advanced Materials	Polymer Liquid Crystals	●								
	Dynamics of Charge Density Waves		●							
	Electronic Structures			●	●					
	Super Lattices					●				
Biopolymers										
	Two Dimensional Colloids	●								
	Colloidal Liquid Crystals						●			
	NMR Studies							●		

Brandeis University

Rosenstiel Center

MCEC Topic	Faculty Subtopic	Caspar, D.	Cohen, C.	DeRosier, D.						
Biopolymers										
	Liquid and Colloid Crystals	●								
	Fibrous Protein & Dynamics		●							
	Actin Filaments			●						

Faculty Name

Harvard University

Chemistry Dept

MCEC Topic	Faculty Subtopic	Barron, A.	Whitesides, G.
Advanced Materials	Inorganic/Organometallic Polymers	●	●
	Precursors for Ceramics	●	●
	Composites	●	●
Manufact./Proc. Fabrication			
	Surface Chemistry		●
Biopolymers			
	Polysaccharides		●
Environment			
	Purification of Organometallics	●	

Southeastern Massachusetts University

Chemistry Dept
Electrical/Computer Engineering Dept*

Faculty Name

MCEC Topic	Faculty Subtopic	Wu, C.	*Chen, C.
Advanced Materials	Polymer Synthesis	●	
	Polymer Characterization	●	
	Ultrasonic NDT		●
	Signal Processing in NDT		●
	Expert System for NDT		●
	NDT= Non Destructive Testing		

Boston University

Physics Dept

MCEC Topic	Faculty Subtopic	Rothschild, K.	Makowski, L.	Braiman, M.	Bansil, R.	Redner, S.	Klein, W.	Stanley, H.		
		Faculty Name								
Advanced Materials	Rheology					●	●	●		
	Gels				●	●	●	●		
	Polymer Characterization	●		●	●					
	Polymer Chemistry	●		●	●					
	Fractals					●	●			
	Polymerization/Phase Separation				●	●	●			
	Composites					●	●	●		
	Synthesis	●		●						
Biopolymers										
	Genetic Engineering	●	●	●						
	Molecular Spectroscopy	●		●						
	X-Ray Diffraction		●							
	Nanostructure Fabrication	●								
	Proton Transport	●		●						
	Viruses		●							
	Lipid Membrane				●		●			
	Prosthetic Materials							●		
	Nerve Cell Design							●		
	Controlled Drug Release							●		